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ART. XXXIV.—*Remarks concerning the Flora of North America;* by ASA GRAY.

[Read to the Botanists at the meeting of the American Association for the Advancement of Science, at Montreal, August 25, 1882.]

IN the remarks which I have to offer to this Section, you will understand the word *Flora* to be written with a capital initial. I am to speak of the attempts made in my own day, and still making, to provide our botanists with a compendious systematic account of the phænogamous vegetation of the whole country which the American Association calls its own.

I shall make no effort to avoid the personal turn which my narrative is likely to take. In fact, it will be seen that I have partly a personal object in drawing up this statement.

Only two Floras of North America have ever been published as completed works, that of Michaux and that of Pursh. A third was begun (by Dr. Torrey, assisted by a young man who is no longer young), by the publication in the summer of 1838 of a first fasciculus; the first volume of 700 pages was issued two years afterward; and 500 pages of the second volume appeared in 1841 and in the early part of 1843. The time for continuing it in the original form has long ago passed by. Its completion in the form in which I have undertaken it anew, is precarious. *Precarious* in the original sense of the word, for it

is certainly to be prayed for: precarious, too, in the current sense of the word as being uncertain; yet not so, according to an accepted definition, viz: "uncertain, because depending upon the will of another;" for it is not our will but our power that is in question; and it is only by the combined powers and efforts of all of us interested in Botany that the desired end can possibly be attained.

It were well to consider for a moment how and why it is that a task which has twice been—it would seem—easily accomplished has now become so difficult.

The earliest North American Flora, that of the elder Michaux, appeared in the year 1803. It was based entirely upon Michaux's own collections and observations, does not contain any plants which he had not himself gathered or seen, is not, therefore, an exhaustive summary of the botany of the country as then known, and so was the more readily prepared. Michaux came to this country in 1785, returned to France in 1796, left it again in Baudin's expedition to Australia in 1800, and died of fever in Madagascar in 1802. The Flora purports to be edited by his son, F. A. Michaux, who signed the classical Latin preface. The finish of the specific characters, and especially the capital detailed characters of the new genera, reveal the hand of a master; and tradition has it that these were drawn up by Louis Claude Richard, who was probably the ablest botanist of his time. This tradition is confirmed by the fact that Richard's herbarium (bequeathed to his son, and now belonging to Count Franqueville), contains an almost complete set of the plants described, and I found that the specimens of Michaux supplied to Willdenow's herbarium at Berlin were ticketed and sent by Richard. Not only the younger Richard but Kunth also habitually cited the new genera of the work as of Richard, and some others have followed this example. Singularly enough, however, there is no reference whatever to Richard in any part of the Flora, nor in the elaborate preface. The most venerable botanist now living told me that there was a tradition at Paris that Richard performed a similar work for Persoon's *Synopsis Plantarum*, and that he declined all mention of his name in the Synopsis and in the Flora, because the two works—contrary to the French school—were arranged upon the Linnæan Artificial System. He had his way, and the tradition may be preserved in history; but his name cannot be cited for the genera *Elytraria*, *Micranthemum*, *Elodea*, *Stipulicida*, *Dichromena*, *Oryzopsis*, *Erianthus*, and the like. For, by the record these are of *Michaux*, *Flora Boreali-Americana*, and not of Richard.

Michaux's explorations extended from Hudson's Bay, which he reached by way of the Saguenay, to Florida, as far, at least,

as St. Augustine and Pensacola; he was the first botanical explorer of the higher Alleghany Mountains, and, crossing these mountains in Tennessee, he reached the Mississippi in Illinois, and was as far south as Natchez. His original itinerary, which I once consulted, is preserved by the American Philosophical Society, at Philadelphia, to which it was presented by his son. It ought to be printed. That little journal shows that it was not Michaux's fault that the first Flora of North America was restricted to the district east of the Mississippi River. He had a scheme for crossing the continent to the Pacific. He warmly solicited the government at Washington to undertake such an exploration, and offered to accompany it as naturalist. This may have been the germ or the fertilizing idea of the expedition of Lewis and Clark, which was sent out a few years afterward by Jefferson, to whom, if I rightly remember, Michaux addressed his enterprising proposal.

Leaving out the Cryptogams of lower rank than the Ferns, we find that the Flora of Michaux, published at the beginning of this century, say eighty years ago, contains 1530 species, in 528 genera. No very formidable number; as to species (speaking without a count) little over half as many as are described in my Manual of the Botany of the Northern States, which covers less than half of Michaux's area.

Eleven years afterward, namely, in the year 1814 (the preface is dated December, 1813), appeared the second Flora of North America, namely the *Flora Americæ Septentrionalis*, by Frederick Pursh. This was not confined to the author's own collections, but aimed at completeness, or to give "a systematic arrangement and description of the plants of North America, containing, besides what have been described by preceding authors, many new and rare species, collected during twelve years' travels and residence in that country."

It appears that Pursh was born at Tobolsk, in Siberia, of what parentage we do not know. He himself tells us, in his preface, that he was educated in Dresden, and that he came to this country—to Baltimore and Philadelphia—at the close of the last century, when he must have been only twenty-five years old. He was able to make the acquaintance not only of Muhlenberg, who survived until 1815, and of Wm. Bartram, who died in 1823, but also of the veteran Humphrey Marshall, who died in 1805. His early and principal patron was Dr. Benjamin Smith Barton, who supplied the means for most of the travels which he was able to undertake, and who, as Pursh states, "for some time previous had been collecting materials for an American Flora." Pursh's personal explorations were not extensive. From 1802 till 1805 he was in charge of the

gardens of Wm. Hamilton, near Philadelphia. In the spring of the latter year, as he says, he "set out for the mountains and western territories of the Southern States, beginning at Maryland and extending to the Carolinas (in which tract the interesting high mountains of Virginia and Carolina took my particular attention), returning late in the autumn through the lower countries along the sea-coast to Philadelphia." But, in tracing his steps by his collections* and by other indications, it appears that he did not reach the western borders of Virginia nor cross its southern boundary into the mountains of North Carolina. The Peaks of Otter and Salt-pond Mountain (now Mountain Lake), were the highest elevations which he attained. Pursh's preface continues: "The following season, 1806, I went in like manner over the Northern States, beginning with the mountains of Pennsylvania and extending to those of New Hampshire (in which tract I traversed the extensive and highly interesting country of the Lesser and Great Lakes), and returning as before by the sea-coast." The diary of this expedition, found among Dr. Barton's papers and collections in possession of the American Philosophical Society, has recently been printed by the late Mr. Thomas Potts James. It shows that the journey was not as extended or as thorough as would be supposed; that it was from Philadelphia directly north to the Pokono Mountains, thence to Onandaga, and to Oswego,—the only point on the Great Lakes reached,—thence back to Utica, down the Mohawk Valley to Saratoga, and north to the upper part of Lake Champlain and to the lesser Green Mountains in the vicinity of Rutland, but not beyond. Discouraged by the lateness of the season, and disheartened—as he had all along been—by the failure and insufficiency of remittances from his patron, Pursh turned back from Rutland on the 22d of September, reached New York on the 1st of October, and Philadelphia on the 5th. The next year (1807) Pursh took charge of the Botanic Garden which Dr. Hosack had formed at New York and afterward sold to the State, which soon made it over to Columbia College.† In 1810, he made a voyage to the West Indies for the recovery of his health. Returning in the autumn of 1811, he landed at Wiscasset, in Maine, "had an opportunity of visiting Professor Peck of Cambridge College, near Boston," and of seeing the alpine plants which Peck had collected on the White

* In herb. Barton and herb. Lambert.

† Expecting, no doubt, that it would be kept up. But "the Elgin Botanic Garden" was soon discontinued. It occupied the block of ground now covered by the buildings of the College, and the surrounding tract—now so valuable—from which the college derives an ample revenue. *Noblesse oblige*, and it may be expected that the College—so enriched—will, before long, provide itself with a botanical professorship, and see to the careful preservation and maintenance of the precious Torrey Herbarium, which it possesses along with other subsidiary herbaria.

Mountains.* At the end of the latter year or early in 1812 he went to England with his collections and notes; and at the close of 1813, under the auspices of Lambert, he produced his Flora, consulting, the while, the herbaria of Clayton, Pallas, Plukenet, Catesby, Morison, Sherard, Walter, and that of Banks. Evidently such consultations and the whole study must have been rapid. The despatch is wonderful. One can hardly understand the ground of the statement made by Lambert to my former colleague, Dr. Torrey, that he was obliged to shut Pursh up in his house in order to keep him at his work.

I know not how Pursh was occupied for the next four years, nor when he came to Canada. But he died here at Montreal, in 1820, at the early age of forty-six. More is probably known of him here. If I rightly remember, his grave has been identified, and a stone placed upon it inscribed to his memory.† A tradition has come down to us—and it is partly confirmed by a statement which Lambert used to make, in reference to the vast quantity of beer he had to furnish during the preparation of the Flora—that, in his latter days, our predecessor was given to drink, and that his days were thereby shortened.

In Pursh's Flora we begin to have plants from the Great Plains, the Rocky Mountains, and the Pacific Coast, although the collections were very scanty. The most important one which fell into Pursh's hands was that of about 150 specimens, gathered by Lewis and Clark on their homeward journey from the mouth of Columbia River. A larger collection, more leisurely made on the outward journey, was lost. Menzies in Vancouver's voyage had botanized on the Pacific coast, both in California and much farther north. Some of his plants were seen by Pursh in the Banksian Herbarium, and taken up. I may here say that in the winter of 1838–39 I had the pleasure of making the acquaintance of the venerable Menzies, then about ninety-five years old.

* It is at Wiscasset, therefore, that Pursh's "*Plantago cucullata* Lam. . . . . in wet rocky situations, Canada and Province of Maine," is to be sought. Mr. Pringle has recently found the related *P. Cornuti* (which may be the plant meant), in Lower Canada, not far from the other side of Maine.

It must have been in Professor Peck's herbarium (no longer extant), that Pursh saw what he took to be *Alchemilla alpina*, which he marks "*v. s.*" and refers to from memory only, probably mistakenly. For it has not since been detected either in Vermont or New Hampshire, or anywhere in North America; and Pursh's Journal makes it certain that he did not reach any alpine region in the Green Mountains.

† In the Canadian Naturalist, Principal Dawson gives a brief account of the transference of the remains of Pursh from a grave-yard below Montreal, in which they were interred, to the beautiful Mount Royal Cemetery, where they rest in a lot purchased for the purpose and under a neat and durable granite monument, provided by the naturalists of Montreal and their friends. A small company of botanists, led by Dr. Dawson, visited the spot shortly after the reading of this paper. We learned that Pursh had botanized largely in Canada, in view of a Canadian Flora, and that his collections were consumed by a fire at Quebec shortly before his death, to his extreme discouragement.

In the Supplement, Pursh was able to include a considerable number of species, collected by Bradbury on the Upper Missouri, in what was then called Upper Louisiana,—much to the discontent of Nuttall, who was in that region at the same time, and who, indeed, partly and imperfectly anticipated Pursh in certain cases, through the publication by the Fraser's of a catalogue of some of the plants collected by Nuttall.

To come now to the extent of Pursh's Flora, published nearly sixty-nine years ago. It contains 740 genera of Phænogamous and Filicoid plants, and 3076 species. Just about double the number of species contained in Michaux's Flora of eleven years before.

I must omit all mention of more restricted works, even such as Nuttall's Genera of North American Plants, which came only four years after Pursh's Flora; also the Flora Boreali-Americana of Sir Wm. Hooker, which began in 1829, but was restricted to British America. I cannot say how early it was that my revered master, Dr. Torrey, conceived the idea of the Flora which he at length undertook. But he once told me that he had invited Nuttall to join him in the production of such a work, and that Nuttall declined. This must have been as early as the year 1832, that is, half a century ago. My correspondence with Dr. Torrey began in the summer of 1830, when I was a young medical student, and three or four years afterward I joined him at New York and became, for a short time, his assistant, for all the rest of his life his botanical colleague. He was very much occupied with his duties as professor, chiefly of chemistry; he had not yet abandoned the idea of completing his Flora of the Northern and Middle States, the first volume of which was finished in 1824, while yet free from all professional cares. Although working in the direction of the larger undertaking, the *Flora of North America* did not assume definite shape before the year 1835. I believe that some of the first actually-prepared manuscript for it was written by myself in that or the following year. I was then and for a long time expecting to accompany the South Pacific Exploring Expedition, as originally organized under the command of Commodore Ap. Catesby Jones, but which was subject to long delay and many vicissitudes; during which, having plentiful leisure, I tried my 'prentice hand upon some of the earlier natural orders. Before the expedition, as modified, was ready to sail, under the command of Capt. Wilkes, I had accepted Dr. Torrey's proposal that I should be his associate in the work upon which I had made a small beginning as a volunteer. Two parts, or half of the first volume (360 pages), of this Flora, were printed and issued in July and October, 1838.

It was thought at first, in all simplicity, that the whole task could be done at something like this rate. But, apart from other considerations, it soon became clear that there had been no proper identification of the foundation-species of the earlier botanists, from Linnæus downward; and that our Flora could not go on satisfactorily without this. Dr. Torrey had, indeed, some years before, made a hasty visit to Hooker at Glasgow, to London, and to Paris; but the taking of a few notes upon some particular plants in the herbaria of Hooker, Lambert, and Michaux, and the acquisition, from Hooker, of a good set of the Arctic plants of the British explorers, was about all that had been done. I proposed to attempt something more; so, taking advantage of a favorable opportunity, I sailed for Liverpool in November, 1838, and devoted a good part of the ensuing year to the examination of the principal herbaria, which I need not here specify, in Scotland (where the important one of Sir Wm. Hooker still remained), England, France, Switzerland and Germany, namely those which contained the specimens upon which most of the then-published North American species had been directly or indirectly founded, especially those of Linnæus and Gronovius, of Walter, of Aiton's Hortus Kewensis, Michaux, Willdenow, Pursh, and the later ones of DeCandolle and Hooker.*

After my return the work made good progress: the remaining half of the first volume was brought out in the spring of the year 1840, and by the spring of 1843 the 500 pages of the second volume, mostly occupied by the vast order Compositæ, had been issued. But meanwhile I had in my turn to assume professorial duties and incident engagements,—with the result that, although the study of North American plants was at no time pretermitted, either by Dr. Torrey while he lived, or by myself, we were unable to continue the publication during my associate's life-time; and it was only recently, in the spring of 1878, that I succeeded in bringing out, in a changed form, another instalment of the work, completing the *Gamopetalæ*.

In the interval I had made two year-long visits to Europe for botanical investigation, the first partly relating to the botany of the South Pacific, the second wholly in view of the North American flora. And since this last publication still another visit—the fourth and we may suppose the last—of the same character and the same duration, has been successfully accomplished.

The serious question, in which we are all concerned, arises, whether this work can be carried through to a completion, and the older parts (wholly out of print and out of date), re-elabo-

* See, in this connection, "Notices of European Herbaria, particularly those most interesting to the North American Botanist," in this Journal, vol. xi, January, 1840.

rated—I will not say by my hands—but in my time, or soon enough to render the whole a reasonably full and homogeneous representation of the North American flora, as known in this latter part of the nineteenth century. And it brings us to consider why the undertaking to which so much time has been devoted, should be so slow of accomplishment.

If this slowness is a constant wonder and disappointment to most people interested in the matter, I can only add that it is hardly less so to myself. It is a constant surprise—if one may so say—that the work does not get on faster.

Of course the undertaking has become more and more formidable with the enlargment of geographical boundaries and of the number of species discovered. As to the increase in the number of species to be treated, we have by no means yet reached the end. The area, that of our continent down to the Mexican line, we trust is definitely fixed, at least for our day. And, since we cannot be rid of the peninsula and keys of Florida, which entails upon us a considerable number of tropical species, mostly belonging to the West Indies—the southern boundary is now as natural a one as we can have.

The area which Pursh's Flora covered was, we may say, the United States east of the Mississippi, with Canada to Labrador, to which was added a couple of hundred of species known to him outside these limits northwestward.

Torrey and Gray's Flora took the initiative in annexing Texas, ten years before its political incorporation into the Union; although the only plants we then possessed from it were certain portions of Drummond's collections. California was also annexed at the same time, on account of Douglas's collections, and those of Nuttall, who had just returned from his visit to the western coast, which he reached by a tedious journey across the continent over ground in good part new to the botanist. Douglas had already made remarkably full collections along a more northern line. The British arctic explorers, both by sea and land, had well developed the botany of the boreal regions, and Sir Wm. Hooker was bringing out the results in his Flora of British America. Of course our knowledge of the whole interior and western region was small indeed, compared with the present; and the botany of a vast region from the western part of Texas to the Californian coast was absolutely unknown, and so remained until after the publication of the Flora was suspended.

As to the number of species which Torrey and Gray had to deal with, I can only say that a rapid count gives us for the first volume about 2200 Polypetalæ; that there are 109 species in the small orders which in the second volume precede the *Compositæ;* and that there are of the *Compositæ* 1054. So one

may fairly conclude that if the work had been pushed on to completion, say in the year 1850, the 3076 species of Pursh's Flora in the year 1814 might have been just about doubled. Probably more rather than less; for if we reckon from the number of the *Compositæ*, and on the estimate that they constitute one-eighth of the phænogamous plants of North America, instead of 6150, there would have been 8430 species known in the year specified.

It most concerns us to know the number of species which, after the lapse of thirty years more—years in which exploration has been active, and has left no considerable part of our great area wholly unvisited—the now revived Flora has to deal with. We can make an estimate which cannot be far wrong. In the year 1878, my colleague, Mr. Watson, finished and published his Bibliographical Index to the Polypetalæ of North America, covering, that is, the same ground as the first volume of Torrey and Gray's Flora, completed in 1840. In it the 2200 species of the latter date are increased to 3038. The "*Gamopetalæ* after *Compositæ*" in the Synoptical Flora, brought out in the same year, contains 1656 species. The two together must make up half of our phænogamous botany, that is, adding the increase of the last four years, about 5000 species. And so Mr. Watson adopts the estimate of 10,000 species for our known Phænogams and Ferns. My impression is that the species of *Compositæ* have increased at a rate which, unless they exceed the eighth part of our Phænogams, will warrant a still higher estimate. The number of introduced species of various orders, which will have to be enumerated and most of them described, is, unhappily, fast increasing;* and new indigenous species are almost daily coming to us from some part or other of our wide territory. So that the 10,000 species of this estimate may before long rise to eleven or twelve thousand. Only the experienced botanist can form a just idea of what is involved in the accurate discrimination and proper coördination of 10–12000 species, and in the putting of the results into the language and form which may make our knowledge available to learners or to succeeding botanists.

Moreover, there is of late an *embarras des richesses* which is becoming serious as respects labor and time. The continued and ever increasing influx of materials to Cambridge, beneficial as it ever is, is accountable for this retardation of progress in a greater degree than almost any one would suppose. The herbarium, upon whose materials this work is mainly done, and which has been, like the Temple, full forty and six years in building, has received the contributions of two generations of

* I say "unhappily," for they adulterate the natural character of our flora, and raise difficult questions as to how much of introduction and settlement should give to these denizens the rights of adopted citizens.

botanists, and the Torrey herbarium goes back one generation further. Still the number of American specimens annually coming to it is greater than in most former years. Apart from the mere selection and care of these, consider how in other ways it affects the rate of progress of the Flora. The incoming of additional specimens may at a glance settle doubts as to the validity of a species; but new specimens are as apt to raise questions as to settle them; more commonly they raise the question as to the limitation and right definition of the species concerned, not rarely, also, that of their validity. When one has only single specimens of related species, the case may seem clear and the definition easy. The acquisition of a few more, from a different region or other conditions, almost always calls for some re-consideration, not rarely for re-construction. People generally suppose that species, and even genera, are like coin from the mint, or bank notes from the printing press, each with its fixed marks and signature, which he that runs may read, or the practised eye infallibly determine. But in fact species are judgments—judgments of variable value, and often very fallible judgments, as we botanists well know. And genera are more obviously judgments, and more and more liable to be affected by new discoveries. Judgments formed to-day—perhaps with full confidence, perhaps with misgiving—may to-morrow, with the discovery of new materials or the detection of some before unobserved point of structure, have to be weighed and decided anew. You see how all this bears upon the question of time and labor in the preparation of the Flora of a great country. If even in old Europe the work has to be done over and over, how much more so in America, where new plants are almost daily coming to hand. It is true that these fall into their ranks, or are adjustable into their proper or probable places, but not without pains-taking and tedious examination.

Of our Flora, it may indeed be said, that "If 'twere done when 'twere done, then 'twere well it were done quickly." But I may have made it clear that, in the actual state of the case, it is likely to be done slowly. At least you will understand why thus far it has been done slowly. As to the future, if it depended wholly upon me, the completion would obviously be hopeless. I need not say that our dependence, for the actual elaboration, must largely be upon associates, upon the few who have the training and the vast patience, and the access to herbaria and libraries, requisite for this kind of work, but above all upon my associate in the herbarium at Cambridge, to whom, being present with us, I will not further allude.

Of course we rely, very much indeed, upon the continued coöperation of all the cultivators of botany in the country; and

it is gratifying to know that their number is increasing, new ones not less zealous than the old, and better equipped, are taking the places of those that have passed away, and some of them extending their explorations over the remotest parts of the land, and into districts where there is most to be discovered. All can help on the work, and all are doing so, by the communication of specimens and of observations. Those within the range of the published manuals and floras get on—or should get on—with only occasional help from us. They should send us notes and specimens to any amount; but they should not ask us to stop to examine and name their plants, except in special cases, which we are always ready enough to take up. Those who collect in regions as yet destitute of such advantages may claim more aid, and we take great pains to render it; partly on our own account, that we may assort their contributions into their proper places, partly for the encouragement of such correspondents, who otherwise would not know what they have obtained, and who naturally like to know when they have made interesting discoveries.

But the scattered and piecemeal study of plants is neither very satisfactory nor safe. And it involves great loss of time, besides interrupting that continuity and concentration of attention which the proper study of any group of plants demands. As respects the orders of plants which are yet to be elaborated for the Flora, and as to plants which require critical study or minute examination, necessarily consuming much time, it is better to defer their complete determination until the groups to which they severally belong are regularly taken in hand.

The coöperation of all our botanical associates is solicited in this regard, as a matter of common interest and advantage. For we are all equally concerned in forwarding the progress of the Flora of North America; and we may confidently expect from our botanical associates their sympathy, their forbearance, and their continued aid.

ART. XXXV.—*Notes on Physiological Optics.* No. 6. *Binocular Union of Spectral Images;* by W. LECONTE STEVENS.

[Read before the Physical Section of the American Association for the Advancement of Science at Montreal, August, 1882.]

IF a sharply defined object be momentarily illuminated by the intense light of the electric spark, a positive and then a negative after image is perceived, neither, however, lasting very long. A negative after-image lasting several minutes may be secured by gazing very steadily on one point of an object which

contrasts sharply with the surrounding area, while the whole is illuminated by the direct beams of the sun, the eyes being at the same time protected from any glare proceeding from other directions. To secure these visual effects some ocular training is necessary, but the perception soon becomes almost as vivid as in ordinary vision. The after-image, being due to fatigue of the retina in certain parts while others remain unfatigued, appears in the direction of the visual line, changing in apparent position with every motion of the eye.

Professor W. B. Rogers* in 1860 published some experiments in the binocular union of after-images from illuminated lines so arranged as to produce the appearance of relief. Perspective after-images were likewise obtained by Wheatstone† and Wundt;‡ but the objection to conclusions drawn from such perceptions as these consists in the fact that the observer knows what effects *would* result in direct vision, under the conditions imposed; and it is difficult to determine how far the perception may be due to imagination rather than to retinal sensation. Professor Rogers succeeded in attaining perspective after-images, even when the luminous lines were regarded successively instead of together; but thus far no one else seems to have recorded the same results, and the experiment is still liable to the objection that the visual judgment is warped by anticipation and association. I have undertaken to test these results as rigidly as possible, and at the same time to ascertain whether any modification would be imposed by varying the muscular conditions under which the spectral images are seen.

1. Across the median plane of vision was held a card, with the upper edge more remote than the center, so that a white band from top to bottom on a dark background, was inclined about 40°. This was fixedly regarded with each eye in succession, while held in direct sunlight, until both retinas were fatigued. On going into a moderately dark room, the inclined spectral image was easily perceived, apparently in mid air. With visual lines parallel it became projected on the wall but without losing its obliquity. On strongly contracting the internal rectus muscles, it appeared still directly in front, but much smaller and nearer. The experiment was repeated many times, and varied, but with uniform results.

2. On separate cards a pair of diagrams were constructed in such manner as to produce an image in relief when binocularly viewed in the stereoscope or otherwise. These were separately and successively regarded in sunlight, each with the appropriate eye. In the dark room the resultant after-image was distinctly perceived in mid air, standing out in bold relief. On

* This Journal, II, xxx, Nov., 1860. † Phil. Transactions, 1838, ii, p. 392.
‡ Opt. Phys., p. 936.

shutting one eye, the component image that remained visible to the other was at once projected upon the wall as a flat picture. Strongly contracting the ciliary muscle of the eye remaining open, without sensibly contracting the rectus muscles, the picture was made to approach and grow apparently smaller, in almost as marked a degree as by the previous experiment.

3. A series of concentric black and white circular bands was constructed on a card, which was held in a vertical plane obliquely crossing the horizontal visual line of the left eye. After the retina became fatigued, the card was held across that of the right eye, but with opposite obliquity, so that the distortions of the elliptic images on the two retinas should be opposite in sense. The resultant spectral image was concave instead of plane, and presented the same variations with change of muscular conditions as in previous experiments.

4. To ascertain whether these perspective stereoscopic effects were due to imagination and association, or whether they were the immediate outcome of retinal sensation, from the existence of dissimilar images remaining through fatigue in the two eyes, it was necessary to test some person whose eyes were normal, but who was ignorant regarding the nature of the visual effects to be produced, and who therefore could not be influenced by anticipation. I enlisted the interest of a young friend, a youth of good general intelligence, but who was entirely unacquainted with even the elementary principles of binocular vision. He submitted to be trained until he could secure monocular after-images successfully with either eye at will. Without granting him the slightest clue by which results could be anticipated, I employed a pair of cards on which were diagrams, so arranged that the binocular resultant could be made either a raised cone, a flat picture, or a hollow cone, according to the mode of combination selected. These cards were viewed in sunlight, never binocularly but always in succession, the relation between the pictures being varied in successive experiments. As soon as the retinas were fatigued the observer was led into a perfectly dark room and requested to describe the resultant spectral images perceived. Without allowing him ever to know whether his visual judgments were right or wrong, I repeated these experiments day after day, until his own conclusions were formed by repeated interpretation of his retinal sensations. His judgments were in the majority of cases correct, and by spectral images alone he learned what was the proper arrangement of pictures to produce a binocular resultant that was concave or convex at will. I substituted then the cards with concentric circular bands; and in like manner he soon learned what kind of obliquity should be given the plane of each card

in order to produce a concave or convex spectral binocular image. His eyes did not have enough muscular power to test the effect of varying the tension in either ciliary or rectus muscles, nor was he able to perceive duplication in any part of any binocular spectral image.

5. A pair of diagrams were constructed in such manner as to show very plainly the binocular duplication of central parts in the background when the foreground was binocularly regarded, and the gaze was monocularly directed to the center of each in succession, with the usual precautions. The spectral image presented the appearance of relief. By an effort of special attention the duplication of the background became perceptible, but at the same moment the appearance of relief was lost.

These experiments, combined with those made under the light of the electric spark, show very conclusively that the *conscious* perception of double images, far from being conducive to clearness of binocular perception, tends rather to interfere with it. If it be said that we *unconsciously* perceive them and distinguish between the two kinds, this conclusion cannot be confirmed or disproven, except so far as experiments like those just detailed may be accepted as having some bearing upon the subject My own disposition is to discard intuition entirely, and, with Helmholtz, to regard the degree of attention bestowed upon objects pictured at the same moment on different parts of the two retinas as an element of more importance than either play of the eyes or the perception of double images. The point in the field of view to which most attention is habitually given is that pictured upon corresponding retinal parts; but the attention is at the same moment divided, being given in less degree to many other parts of the field of view, as simultaneously perceived with each eye. The mental suggestion due to the impression of non-corresponding parts is that of the third dimension in space. If this be called the perception of double images, their effect seems to be dependent upon their *not* emerging into consciousness. Add to this the fact that the gradation between single and double vision is wholly imperceptible, and hence that for infinitesimal departures from single vision, there can be no demonstrable distinction between the two kinds of double images. In the interpretation of our sensations we are certain that experience is our habitual guide, though by no means always a reliable one. Whether intuition can be accepted as an *additional* guide at all, it is not easy to pronounce. The debate between the advocates of the empiristic and nativistic theories is doubtless like the well known quarrel about a certain shield, and may be continued indefinitely. The domain of intuition is certainly more limited than was thought a few generations ago. Whether it can be reduced to zero may per-

haps be decided a few generations hence. In all ordinary cases of binocular vision the judgment is cumulative, the conclusion quickly reached being a product not only of difference in the degree of attention given at the same moment to objects seen by direct and by indirect vision respectively, but also to variation in attention given to different points directly viewed in succession, to the muscular sense while free play is given to the eyes, and to all the elements available in monocular vision, which I have grouped together under the name of physical in contrast with physiological perspective.

ART. XXXVI.—*New views of Mr. George H. Darwin's Theory of the Evolution of the Earth-Moon System, considered as to its bearing on the question of the duration of Geological Time;* by the Rev. SAMUEL HAUGHTON, M.D., Fellow of Trinity College, Dublin.

[Read before the Mathematical Section of the American Association for the Advancement of Science, at Montreal, August, 1882.]

IT has been tacitly assumed, even so far back as the times of Newton and Clairaut, that the earth and planets have passed through a liquid condition (owing to former great heat) before assuming the solid condition, which some, at least, of them now possess.

Laplace, in his nebular hypothesis, also assumes the former existence of this liquid condition, and it is openly asserted by all geologists who believe that the earth consists of a solid crust (more or less thick), reposing upon a fluid or viscous nucleus.

It has been proved by Sir William Thomson, following out the views of the late Mr. Hopkins, that the present condition of the earth, taken as a whole, is such that it must be regarded as being more rigid than glass or steel, possibly more rigid than any terrestrial substance under the surface conditions of pressure.

The following considerations show that it may be fairly doubted whether the earth or any other planet ever existed in a fluid condition.

1. The possibility of the equilibrium of the rings of Saturn, on the supposition that they are either solid or liquid has been more than doubted, and the most probable hypothesis respecting them is, that they consist of swarms of discrete meteoric stones.

2. It is difficult to understand the low specific gravity of Jupiter and the other outer planets, on the supposition that they are either solid or liquid, for we know of no substance

light enough to form them.* If the outer planets consist of discrete meteoric stones moving around a solid or liquid nucleus, the difficulty respecting their specific gravity would disappear.

3. The recent researches connecting the November, the August, and other periodic swarms of shooting stars with comets tend in the direction of showing that comets in cooling, break up into discrete solid particles (each no doubt having passed through the liquid condition); and that probably the solar nebula cooled in like manner into separate fiery tears, which soon solidified by radiation into the cold of space.

4. Mr. Huggins's recent comparisons of the spectroscopic appearances of comets and incandescent portions of meteoric stones, showing the presence in both of hydrocarbon and nitrogen compounds, confirm the conclusions drawn from the identity of the paths of comets and meteoric periodic shooting stars.

5. Mr. H. A. Newton, in a remarkable paper read before the Sheffield Meeting of the British Association (1879), showed the possibility (if not probability) of the asteroids being extinct comets, captured and brought into the solar system by the attraction of some one or other of the outer large planets, and permanently confined in the space between Mars and Jupiter, which is the only prison cell in the solar system large enough to hold permanently such disorderly wanderers.

In the same paper, Professor Newton threw out the idea that some of the satellites of the large planets might also be of cometary origin.

From all these and other considerations it is therefore allowable to suppose that the earth and moon when they separated from the solar nebula, did so as a swarm of solid meteoric stones, each of them having the temperature of interstellar space; i. e. something not much warmer than 460° F. below the freezing point of water.

Mr. George H. Darwin has shown, admirably, how the earth-moon system may have been developed from the time when the earth-moon formed one planet revolving on its axis in a few hours, to the present time, when the earth and moon (in consequence of tidal friction) have pushed each other asunder to a distance of sixty times the radius of the earth.†

In his paper on the tidal friction of a planet‡ (supposed viscous and under the influence of bodily tides caused in it by an external body such as the moon), Mr. Darwin has found a remarkable equation of condition, which may be thus expressed:

* The force of this argument could not be felt before the revelations of the spectroscope, because at that time there was no proof that the whole universe was composed of the same simple substances, and those very limited in number.

† Proceedings of Royal Society, 19th June, 1879.

‡ Phil. Trans., 1881, Part ii, p. 494.

$$d(\sqrt{r}) \propto \frac{\Psi dt}{r^6} \tag{1}$$

where r = distance between centers of earth and moon.
t = time elapsed from a fixed epoch.

$$\Psi = \frac{p(n-\Omega)}{1+p^2(n-\Omega)^2} \tag{2}$$

n = angular velocity of earth's rotation.
Ω = angular velocity of moon's orbital revolution.
p = quantity varying inversely as the viscosity of the planet.

The extreme interest of equation (1) consists in the appearance of the inverse sixth power of the distance.

As the function Ψ varies very slowly, we find by integration, for any portion of time during which Ψ may be regarded as constant

$$t = Ar^{\frac{13}{2}} + B, \tag{3}$$

a most unexpected and remarkable result.

Upon reading Mr. Darwin's papers, my mind turned to a problem with which I was familiar, viz: the retardation of the earth's rotation produced by the lunisolar tide exerted upon the ocean supposed collected in an equatorial canal, the moon and sun having no declination, and I readily found an equation to express the evolution of the earth-moon system, on the foregoing hypothesis as to friction.

This equation is the following:

$$d(\sqrt{r}) \propto \frac{f\Phi dt}{r^6} \tag{4}$$

where

$$\Phi = \frac{V_0(n-\Omega)}{\{4V_0^2(n-\Omega)^2-k^2\}\sqrt{4(n-\Omega)^2+f^2}} \tag{5}$$

f = coefficient of friction supposed proportional to relative velocity.
k varies inversely as r^3.
V_0 = velocity at earth's equator.

This leads, as in Mr. Darwin's hypothesis of viscous earth, to the integral

$$t = A'r^{\frac{13}{2}} + B' \tag{6}$$

The form of the functions Ψ and Φ is similar, as both ascend by odd powers of $(n-\Omega)$ and vanish when $n=\Omega$, that is to say, at the beginning and end of the evolution by friction of the earth-moon system.

It is quite clear, therefore, that the remarkable expression (1) found by Mr. Darwin, is not peculiar to his special hypothesis of a viscous earth, but can be deduced equally well from the totally distinct hypothesis of an absolutely rigid earth retarded by the tidal action of a liquid ocean.

I was led by this result to consider the case of the earth-moon separating (as I believe they did) from the central solar mass, in the form of a swarm of discrete masses of meteoric iron and stone, each one having the temperature of the cold of interstellar space, or not much above it. Translating this conception into mathematical language, I find that the equation of continuity belonging to the hydrodynamical theory applies equally well to the meteoric theory, viz:

$$vy = v'y' \qquad (7)$$

where v, v', are the velocities at any two points, and y, y' are the depths of the ocean or meteoric swarm at the same points.

The depth of the swarm or ocean, without jostling or friction will be least under the moon, and greatest at right angles to the moon, and the velocities will be inversely. Hence the chances of jostling among the meteorites, when disturbed by the moon's tidal action will be proportional to the velocity, being greatest where the velocity is greatest and the area of passage least, and *vice versa*.

This consideration reduces the meteoric problem to that of the hydrodynamical problem, with a friction proportional to the velocity, and gives equations, in all respects similar to those derived by Mr. Darwin, from the hypothesis of a viscous earth.

On the meteoric hypothesis, if the jostling of the stones be slow they may cool almost as fast as they are heated and the result will be a cool earth and almost indefinite time at the disposal of geologists.

Art. XXXVII.—*Recent discoveries in the Erian (Devonian) Flora of the United States;* by J. W. Dawson.

The following notes are extracted from a Report on Devonian Plants prepared for the Geological Survey of Canada, but not yet published. They relate to the recent discoveries made in the United States, and their bearing on points of interest with reference to the Erian Flora.

I. The Nature and Affinities of Ptilophyton.

(*Lycopodites Vanuxemii* of Report on Devonian and Upper Silurian Plants, Pt. I, p. 35.—*L. plumula* of Report on Lower Carboniferous Plants, p. 24, Pl. I, figs. 7, 8, 9.)

In previous publications these remarkable pinnate frond-like objects were referred to the genus *Lycopodites*, as had been done by Gœppert in his description of the European species *Lycopodites pennæformis*, which is very near to the American Erian form. Since 1871, however, there have been many new specimens

obtained, and very various opinions expressed as to their affinities. While Hall has named some of them *Plumalina* and has regarded them as animal structures, allied to hydroids, Lesquereux has described some of the Carboniferous forms under the generic name *Trochophyllum*, which is however more appropriate to plants with verticillate leaves which are included in this genus. Before I had seen the publications of Hall and Lesquereux on the subject, I had in a paper on Scottish Devonian Plants,* separated this group from the genus *Lycopodites* and formed for it the genus *Ptilophyton*, in allusion to the feather-like aspect of several of the species. My reasons for this, and my present information as to their nature may be stated as follows:

Schimper, in his "Paléontologie Végétale," (possibly from inattention to the descriptions or want of access to the specimens) doubts the Lycopodiaceous character of species of *Lycopodites* described in my published papers on plants of the Devonian of America and in my Report of 1871. Of these *L. Richardsoni* and *L. Matthewi* are undoubtedly very near to the modern genus *Lycopodium*. *L. Vanuxemii* is, I admit, more problematical; but Schimper could scarcely have supposed it to be a fern or a fucoid allied to *Caulerpa* had he noticed that both in my species and the allied *L. pennæformis* of Gœppert, which he does not appear to notice, the pinnules are articulated upon the stem, and leave scars where they have fallen off. When in Belfast in 1870, my attention was again directed to the affinities of these plants by finding in Professor Thomson's collection a specimen from Caithness, which shows a plant apparently of this kind, with the same long narrow pinnæ or leaflets, attached, however, to thicker stems, and rolled up in a circinate manner. It seems to be a plant in vernation, and the parts are too much crowded and pressed together to admit of being accurately figured or described; but I think I can scarcely be deceived as to its true nature. The circinate arrangement in this case would favor a relationship to ferns; but some Lycopodiaceous plants also roll themselves in this way, and so do the branches of the plants of the genus *Psilophyton*.

The specimen consists of a short erect stem, on which are placed somewhat stout alternate branches, extending obliquely outward and then curving inward in a circinate manner. The lower ones appear to produce on their inner sides short lateral branchlets, and upon these and also upon the curved extremities of the branches, are long narrow linear leaves placed in a crowded manner. The specimen is thus not a spike of fructification, but a young stem or branch in vernation, and which when unrolled would be of the form of those peculiar pinnate

* Canadian Naturalist, 1878.

Lycopodites of which *L. Vanuxemii* of the American Devonian and *L. pennæformis* of the European Lower Carboniferous are the types, and it shows, what might have been anticipated from other specimens, that they were low tufted plants, circinate in vernation.

As these plants constitute a small but distinct group, known only, so far as I am aware, in the Lower Carboniferous and Erian or Devonian, they deserve a generic name, and I proposed for them in my Paper on Scottish Devonian Plants, 1878, that of *Ptilophyton*, a name sufficiently distinct in sound from Psilophyton, and expressing very well their peculiar feather-like habit of growth. The genus was defined as follows:

"Branching plants, the branches bearing long slender leaves in two or more ranks, giving them a feathered appearance; vernation circinate. Fruit unknown, but analogy would indicate that it was borne on the bases of the leaves or on modified branches with shorter leaves."

The Scottish specimen above referred to was named *Pt. Thomsoni*, and was characterized by its densely tufted form and thick branches. The other species known are:

Pt. pennæformis Gœppert, L. Carboniferous.
Pt. Vanuxemii Dawson, Devonian.
Pt. plumula Dawson, L. Carboniferous.

Shumard's *Filicites gracilis*, from the Devonian of Ohio, and Stur's *Pinites antecedens*, from the Lower Carboniferous of Silesia, may possibly belong to the same genus. The Scottish specimen referred to is apparently the first appearance of this form in the Devonian of Europe.

I have at a still later date had opportunities of studying considerable series of these plants collected by Professor Williams of Cornell University, and have prepared a note in reference to them for the American Association, of which, however, only an abstract has been published. I have also been favored by Professor Lesquereux and Mr. Lacoe of Pittston, with the opportunity of studying the specimens referred to *Trochophyllum*.

Professor Williams's specimens occur in a dark shale associated with remains of land plants of the genera *Psilophyton*, *Rhodea*, etc., and also marine shells, of which a small species of *Rhynchonella* is often attached to the stems of the *Ptilophyton*. Thus these organisms have evidently been deposited in marine beds, but in association with land plants.

The study of the specimens collected by Professor Williams developes the following facts: (1.) The plants are not continuous fronds, but slender stems or petioles with narrow linear leaflets attached in a pinnate manner. (2.) The pinnules are so articulated that they break off leaving delicate transverse scars, and the lower parts of the stems are often thus denuded

of pinnæ for the length of one or more inches. (3.) The stems curve in such a manner as to indicate a circinate vernation. (4.) In a few instances the fronds were observed to divide dichotomously toward the top; but this is rare. (5.) There are no indications of cells on the pinnules; but, on the other hand, there is no appearance of fructification unless the minute granules which roughen some of the stems are of this nature. (6.) The stems seem to have been lax and flexuous, and in some instances they seem to have grown on the petioles of ferns preserved with them in the same beds. (7.) The frequency of the attachment of small brachiopods to the specimens of *Ptilophyton* would seem to indicate that the plant stood erect in the water. (8.) Some of the specimens show so much carbonaceous matter as to indicate that the pinnules were of considerable consistency. All these characters are those rather of an aquatic plant than an animal organism or a land plant.

The specimens communicated by Professor Lesquereux and Mr. Lacoe are from the Lower Carboniferous, and evidently represent a different species with similar slender pitted stems, often partially denuded of pinnules below; but the pinnules are much broader and more distant. They are attached by very narrow bases, and apparently tend to lie on a plane, though they may possibly have been spirally arranged. On the same slabs are rounded sporangia or macrospores like those of *Lepidodendron*, but there is no evidence that these belonged to *Trochophyllum*. On the stems of this plant, however, there are small rounded bodies apparently taking the places of some of the pinnules. These may possibly be spore-cases; but they may be merely imperfectly developed pinnules. Still the fact that similar small granules appear on the stems of the Devonian species, favors the idea that they may be organs of fructification.

The most interesting discovery, however, which results from the study of Mr. Lacoe's specimens, is that the pinnules were cylindrical and hollow, and probably served to float the plant. This would account for many of the peculiarities in the appearance and mode of occurrence of the Devonian *Ptilophyton*, which are readily explained if it is supposed to be an aquatic plant, attaching itself to the stems of submerged vegetable remains and standing erect in the water by virtue of its hollow leaves. It may well, however, have been a plant of higher organization than the algæ, though no doubt Cryptogamous.

The species of *Ptilophyton* will thus constitute a peculiar group of aquatic plants, belonging to the Devonian and Lower Carboniferous periods, and perhaps allied to Lycopods and Pillworts in their organization and fruit, but specially distinguished by their linear leaves serving as floats and arranged pinnately on slender stems. The only species yet found within

the limits of Canada is *Pt. plumula* found by Dr. Honeyman in the Lower Carboniferous of Nova Scotia; but as *Pt. Vanuxemii* abounds in the Erian of New York, it will no doubt be found in Canada also.

II. Note on Erian Trees of the Genus Dadoxylon, Unger (*Araucarites* of Gœppert, *Araucarioxylon* of Krans.)

Large woody trunks, carbonized or silicified, and showing wood-cells with hexagonal areoles having oval pores inscribed in them, occur abundantly in some beds of the Middle Erian in America, and constitute the most common kind of fossil wood all the way to the Trias. They have in the older formations, generally, several rows of pores on each fiber, and medullary rays composed of two or more series of cells, but become more simple in these respects in the Permian and Triassic series. The names *Araucarites* and *Araucarioxylon* are perhaps objectionable, inasmuch as they suppose affinities to *Araucaria* which may not exist. Unger's name, which is non-committal, is therefore, I think, to be preferred. In my Acadian Geology and in my Report on the Geology of Prince Edward Island, I have given reasons for believing that the foliage of some at least of these trees was that known as *Walchia*, and that they may have borne nutlets in the manner of Taxine trees (*Trigonocarpum*, etc.). Grand d'Eury has recently suggested that some of them may have belonged to *Cordaites*, or to plants included in that somewhat varied and probably artificial group.

The earliest discovery of trees of this kind in the Erian of America, was that of Matthew and Hartt, who found large trunks, which I afterwards described as *Dadoxylon Ouangondianum*, in the Erian Sandstone of St. John, New Brunswick, hence named by those geologists the "Dadoxylon sandstone." A little later, similar wood was found by Professor Hall and Professor Newberry in the Hamilton group of New York and Ohio, and the allied wood of the genus *Ormoxylon* was obtained by Professor Hall in the Portage group of the former State. These woods proved to be specifically distinct from that of St. John, and were named by me *D. Halli*, *D. Newberryi*, and *Ormoxylon Erianum*. The three species of *Dadoxylon* agreed in having composite medullary rays, and would thus belong to the group *Palæoxylon* of Brongniart. In the case of *Ormoxylon* this character could not be very distinctly ascertained, but the medullary rays appeared to be simple.

I am indebted to Professor J. M. Clarke of Amherst College, Massachusetts, for some well preserved specimens of another species from the Genesee shale of Canandaigua, New York. They show small stems or branches, with a cellular pith surrounded with wood of Coniferous type, showing two to three

rows of slit-formed bordered pores in hexagonal borders. The medullary sheath consists of pseudo-scalariform and reticulated fibers; but the most remarkable feature of this wood is the structure of the medullary rays, which are very frequent, but short and simple, sometimes having as few as four cells superimposed. This is a character not before observed in Coniferous trees of so great age, and allies this Middle Erian form with some Carboniferous woods which have been supposed to belong to Cordaites or Sigillaria. In any case this structure is new, and I have named the species *Dadoxylon Clarkii*, after its discoverer. The specimens occur, according to Professor Clarke, in a calcareous layer which is filled with the minute shells of *Styliola fissurella* of Hall, believed to be a Pteropod; and containing also shells of *Goniatites* and *Gyroceras*. The stems found are only a few inches in diameter, but may be branches of larger trees.

It thus appears that we already know five species of Coniferous trees of two genera in the Middle Erian of America, an interesting confirmation of the facts otherwise known as to the great richness and variety of this ancient flora. Professor Gœppert informs me that he has recently recognized similar wood in the Devonian of Germany, and there can be no doubt that the fossil wood discovered by Hugh Miller in the Old Red Sandstone of Scotland, and described by Salter and McNab, is of similar character, and probably belongs to the genus *Dadoxylon*. Thus this type of Coniferous trees seems to have been as well established and differentiated into species in the Middle Devonian as in the succeeding Carboniferous.

III. The Genus Cladoxylon in America.

In the Report of the Fossils of the Devonian rocks of Thuringia, by Unger and Richter,* the former has described and figured certain fossil stems showing structure, to which he gives the name *Cladoxylon*, and makes them the types of a Family *Cladoxyleæ*, which he regards as allied to Lycopods. He describes the stem of *C. mirabile* as having a slender cellular pith surrounded by a series of vertical plates of scalariform tissue, adhering internally, and separating and sometimes forking toward the exterior, the whole surrounded by a thick cellular investment.

Professor Clarke has been so fortunate as to find in the *Styliola* limestone, which contains the branches of *Dadoxylon*, a specimen showing the structure of *Cladoxylon*, and so similar to Unger's species, *C. mirabile*, that I think it may safely be referred to it. The stem is 1·5 centimeter in diameter, and marked with about fifteen longitudinal ribs; which are the edges of the

* Vienna, 1856.

radiating plates of scalariform vessels. In the cross section, the axis consists of vertical but wavy radiating bands of pseudoscalariform tissue, with intervening cellular matter. Enclosing the axis is a cylinder of thin-walled cellular tissue traversed by a few bundles of fibers. The outer surface has a dense cortical structure, but unfortunately shows no external markings. This discovery affords another interesting link of connection between the Erian flora of Eastern America and that of Europe.

We know from the rocks and fossils of Gaspé and St. John, that in the Middle Devonian period there was much land on the eastern side of the North American Continent. But at this period the regions of western New York and Ohio and of western Canada, were covered by the sea. It thus happens that the land flora of the Hamilton and associated rocks of the interior portion of the Continent, consists merely of drifted and macerated remains carried out to sea. The number and variety of these remains, however, testify in a remarkable manner to the richness of the flora, representing as they do, though in an imperfect manner, many species of Conifers, Tree-ferns, and Arborescent Lycopods, all of which probably grew on limited insular areas.

To Professor Clarke we are also indebted for the discovery of a remarkable tree of the Hamilton period (*Celluloxylon primævum* Dn.); and Mr. B. M. Wright of Penn Yan, N. Y., has recently added to the plants of the Portage and Chemung the singular types of tree-fern, *Asteropteris Noveboracensis* Dn., an equisetaceous plant, *Equisetites Wrightiana* Dn., and *Cyclostigma affine*, a plant allied to the well-known *Cyclostigma* of the Irish Devonian. These species have been described in the Journal of the London Geological Society for May, 1881.

IV. Psilophyton and Rhodea.

Reference is made to the abundant occurrence of the species *P. princeps* and *P. robustius* in the Lower Erian near Campbellton, and the corroboration which the specimens afford of the author's previous statements as to the structure and affinities of these plants so characteristic of the Erian both in Europe and America.

As it has, however, been suggested by some botanists that *Psilophyton* may have been allied to the ferns of Stur's genus *Rhodea*, I may state here that after the study of hundreds of specimens, in every state of preservation, I have found no trace of any fronds on the branches, but on the barren branches minute acicular leaves, while the spore-cases, though in the form of sacks, having some resemblance to those of *Archæopte-*

ris, are entirely different in their habit of growth, and also very much larger.

In this connection I may mention that in specimens from the Chemung shales of New York, recently obtained from Professor Williams, I have found plants which may be referred to *Rhodea*. They are slender delicately striated or smooth petioles, giving off pinnate divisions, which ultimately bifurcate frequently and appear to terminate in flat blade-like or cuneate leaves or fronds. They are the same objects which I described, from fragmentary specimens obtained from Professor Hall, as *Rhachiopteris pinnata*, in my paper on Devonian plants, in the Journal of the Geological Society of London, vol. xviii. In a note on Professor Williams' plants, presented last year to the American Association for the Advancement of Science, I have described these specimens and have suggested the name *Rhodea pinnata* for them. They may be defined to be stems bearing slender opposite branches in a decussate manner, the branches again dividing in a dichotomous or pinnate mode, and terminating in small cuneate or linear leaves. The fructification of these plants I have not seen, but they are in appearance and habit of growth altogether distinct from *Psilophyton*. I may also observe here that the stems of *Psilophyton* are much more woody, and in their round central scalariform axis, present much more of structural affinity to Lycopods than to Ferns.

ART. XXXVIII.—*Brief Notice of Observations on the Triassic Trap Rocks of Massachusetts, Connecticut and New Jersey;* by W. M. DAVIS.

DURING the past summer I have examined the Triassic trap rocks in Massachusetts, Connecticut and New Jersey at a number of points where they are shown in characteristic development. The detailed statement of these observations will soon be published in the Bulletin of the Museum of Comparative Zoology, Cambridge, with full reference to previous work; in the mean time the following brief account of the results attained is presented.

The traps occur in three distinct conditions: first, in dikes crossing the strata of sandstones and shales; these or similar ones not yet revealed by erosion were undoubtedly the passages of supply for the trap sheets; second, in intruded sheets often of great extent and thickness, lying in nearly all cases conformably between the layers of stratified rocks; third, as overflow sheets poured out during the formation of the sandstone, in thickness and extent equal to the intrusions, and similar to them in topographic effects.

None of the dikes are surely known in Massachusetts, but Connecticut gives numerous examples at Wallingford, East and New Haven and elsewhere; in New Jersey they are rarely seen, but farther southwest they are frequently mentioned. None that I have seen are amygdaloidal; their sides are generally uneven and are sometimes very ragged, implying an eruption before the formation of joints in the sandstone; their metamorphic effect on the adjoining rocks is slight, so far as determined; not extending more than half a foot to two feet from a ten-foot dike, or eight to twelve feet from a hundred-foot dike. The largest dikes that I have seen are Mill and Pine Rocks, New Haven: they are one to two hundred feet thick, of medium coarse texture in the middle, fine at the sides, compact throughout; they break through gently inclined, coarse sandstone strata about at right angles to the bedding, and have a rough transverse columnar structure. It is probable that few of the supply-dikes which fed the largest sheets are yet laid bare.

The intruded sheets are recognized by a distinct metamorphic effect on the strata above as well as below them, and by the absence of amygdaloids; they very probably cut across the adjoining strata at some points, but this cannot always be used for their detection as they are sometimes seen to be evenly interbedded for as much as one hundred feet. They are like the dikes in being younger than the strata which enclose them, but their age is not surely determinate, as will be shown below. The range from West Rock northward from New Haven, and the Palisades along the Hudson are the largest and finest examples: the latter shows as marked a metamorphic effect on the strata on its back as on those below it; the former has produced less alteration, but there is no doubt of its intrusive character. Other smaller intrusions are found along the Delaware. It may be here noted that the Triassic trap sheets have been regarded as intrusive by nearly all authors who have written upon them; Mr. I. C. Russell has recently stated this view of the origin of the First Newark Mountain, N. J. (incorrectly, as I think), as well as for the Palisades. Professor Dana considers all the sheets intrusive, and does not mention overflows in his Manual of Geology, 1880.

The overflow or contemporaneous origin for the trap sheets was first clearly stated by E. Hitchcock, 1833 and 1841; it was later advocated by Principal Dawson for Nova Scotia, and recently by Professor Emerson of Amherst,* but it has never had many advocates.

The overflow sheets are known from being commonly very amygdaloidal on their back or upper surface, and sometimes

* See this Journal for September, 1882.

within the mass or at its base; they exert a small metamorphic effect on the underlying stratum, and none at all on the overlying bed which was deposited conformably upon them. They are sometimes accompanied by a tufaceous deposit, presumably of ashes thrown into the Triassic estuaries; and the overlying sandstone sometimes contains trap fragments. Examples of overflows are the Turner's Falls–Deerfield Range, as lately shown by Emerson; Mts. Holyoke and Tom, first proved by Hitchcock, and their extension southward into Connecticut to the Hanging Hills at Meriden; Lamentation Mountain and some others to the south of it, with their subordinate lateral ranges nearly to Long Island Sound; and First and Second Newark Mountains in New Jersey. The evidence is not equally complete for all of these.

The general history of these Triassic deposits seems to be as follows: Their strata were laid down about horizontally; Rogers' suggestion that their present dip comes from an original oblique deposition cannot be adopted. During their accumulation, heavy sheets of trap overflowed their surface, and sometimes rose above the Triassic waters, so that fragments of trap were mixed with the next formed beds. The common occurrence of foot-prints in the strata not far above the trap is, as was shown Hitchcock, a singular confirmation of this point. These eruptions did not occur simply because the region was disturbed, for many regions of much greater disturbance show no igneous rocks; but very probably because the disturbance was a downfolding and not a general upfolding as in most mountain ranges. The deposition of more strata and the overflow of more trap ceased when the downfolding, that had begun and deepened the Triassic troughs, changed (for some unknown reason) to disturbance with uplifting.

The general monoclinical structure of the several Triassic belts is not considered the result of original oblique deposition as proposed by Rogers; or of broad anticlinal folding as suggested by Kerr and Russell; or of a simple monoclinal tilting as assumed by Hitchcock and LeConte; but is regarded rather as the effect of lateral compression, producing a peculiar distortion. The style of the distortion is best recognized by means of the overflow trap ridges, which are generally continuous for several or many miles; for these, when once proved to be overflows, are established as well marked horizons in the generally monotonous sandstones and shales; satisfactory evidence can thus be obtained to show that the strata as a whole are both folded and faulted. The folds take the form of shallow oval dishes or boats, of gentle curvature, canted over a little and faulted on the side of the general monoclinal dip; and the outcropping edges of the hard trap sheets then neces-

sarily take the crescentic form, first fully recognized by Percival, with their bold convex side toward the up-slope of the monoclinal, and their horns toward the down-slope. The existence of such folds is well proven for several cases by finding that the strike of the neighboring sandstone is closely parallel to the trend of the curved ridge, and that the dip is directed in toward the center of the curve. This has been shown but not fully appreciated by several observers.

Faults are known by the reappearance of certain strata, or series of strata. In this way it may be made very probable that the Hanging Hills sheet reappears in Lamentation Mountain, and again in the several strong ridges as far south as Lake Saltonstall; the face of most if not all of these ridges being characterized by sandstone, amygdaloidal trap, limestone, shale and heavy trap, always occurring in this (ascending) order: smaller examples could also be named. But no sufficient reason has been found to show why a general monoclinal tilting should have taken place.

The New Jersey and Massachusetts areas have few folds and faults shown by trap ridges; they are made on a larger pattern; but faults may occur, unperceived, in their sandstone. Connecticut is decidedly the best field for the study of all the points above mentioned in the history of the Triassic formations.

The age of the intruded sheets has been referred to as indeterminate: it is not as yet susceptible of good limitation. The early writers, who considered all the trap intrusive, often looked on it as the agent of disturbance of the sandstone; later writers, as Dana and Russell, regard it as intrusive after the tilting of the sandstones had been accomplished by some other force. As opposed to these views, I would present the following evidence of its intrusion before the tilting and perhaps nearly contemporaneous with the appearance of the overflows. The dikes and the intruded sheets, where seen to break across the strata, show irregular or ragged edges, as above noted: their intrusion therefore took place before the production of joints, now very distinct in many parts of the sandstone, and hence probably before the tilting, for the joint-making almost surely could not have been later than the tilting and may have been earlier. Moreover, if the intrusions took place during or after the tilting, there is no reason why they might not appear at any part of the Triassic belts; but as a matter of fact the large and well proved intruded sheets occur only near the base of the formation, close to the adjoining crystalline rock; and the only reason that I can assign for so peculiar a limitation is that the interbedded intrusions took place only under a considerable pressure of overlying rocks, as was the

case with the western Laccolites which these intruded sheets resemble in many ways. Finally, the intruded sheets, as well as the overflows, outcrop along curved lines; this curvature in the overflows results from a bending after their eruption; therefore the others also were probably bent after their intrusion. But it must be borne in mind that all of this is only presumptive evidence and not final proof; the age of the intrusions is not yet determined.

Cambridge, Mass., Oct. 5, 1882.

ART. XXXIX.—*The Deerfield Dyke and its Minerals;* by BEN. K. EMERSON, Professor of Geology in Amherst College.

[Concluded from page 278.]

KAOLIN.—Along the shore in Greenfield opposite Turner's Falls, and especially on the new road between these towns, the decomposition of the radiated prehnite has very frequently taken a different course. The nodules are in whole or part changed into a white kaolin (?), the change uniformly commencing from the different centers of radiation and proceeding regularly outward. Under the microscope the kaolin-like material separates into opaque granules so extremely minute that they show in water the Brownian movement with wonderful perfection.

CALCITE.—Among the minerals associated with prehnite we may distinguish those which are enclosed by and themselves enclose the latter, those which are only enclosed in it, and those which are superimposed upon it and are of later formation.

In the first category calcite is the most common. The trap at the base of the prehnite effervesces with acid, and sometimes cleavage surfaces of the latter resemble closely graphic granite on a small scale, the prehnite taking the place of quartz, and if pieces where the calcite is specially abundant be thrown in acid, there remains a delicate frost-work of prehnite on the trap, and similar groups of imperfect crystals are exposed and fall to the bottom of the glass, being surrounded on all sides by calcite. The calcite which is thus intimately associated with prehnite appears at times in quite large masses of transparent Iceland spar; more commonly in white granular portions. Sometimes it is yellow and is perhaps ankerite. The calcite is most abundant immediately after the prehnite and accompanies in varying forms all the later numbers of the series. It also occurs independently in the uppermost layer of the dyke to the depth of a meter in the immediate vicinity of the quartz veins mentioned later, though the two remain

strictly separate. Here it fills large steam pores 10–30^{mm} in diameter, which rise vertically 10–15^{cm}. The walls are coated with a thick layer of diabantite and they are filled with brick-red and transparent calcite in layers.

2. EPIDOTE.—Occurs rarely low down in the prehnite; more commonly in drusy surfaces in its upper part, or spread in delicate tufts of flat blades upon the spindle-shaped crystals. It is included also, with interrupted crystallization, in the calcite which follows upon the prehnite. The maximum size of the crystals is 3^{mm}. They are mostly thick plates, and under the microscope show as brilliant luster and as rich dark green as the specimens from the Dauphiny. It encloses as an aggregate prehnite, sphalerite, chalcopyrite and calcite, but the separate crystals are perfectly pure and transparent. The thickest crystals are deep pistachio green; the thin plates are deep brown-red, sometimes half colorless.

AXINITE.—Jet black, opaque crystals, the largest 10–12^{mm} in length, imbedded in prehnite and calcite and resting on prehnite. The crystals are thick plates, resembling, as do many of the minerals found here, the simpler forms from Bour d'Oisans—the faces P and *u* large and striated vertically, and P also striated horizontally parallel to the intersection edge of P and *r*. The face *r* is smaller and striated horizontally. Rarely the faces *v*, *l* and *s* appear. Two very distinct distant cleavages, especially clear under the microscope, parallel to the two striations upon P, and nearly at right angles to this face, thus nearly cubical. Thin splinters show brilliant trichroism, deep bottle-green, plum blue and clove brown, and are glassy and easily transparent under the microscope, and entirely free from all impurities. The mineral has occurred also at the old locality, east of Deerfield village, and appears in the State Collection, Nos. 86, 87, labeled "Black Augite in Greenstone, Deerfield." Also, opposite Turner's Falls a single perfect crystal 4^{mm} long, black, with shade of brown, resting upon a botryoidal layer of diabantite in an amygdule.

CHALCOPYRITE.—Occurs disseminated in particles in the trap, in the prehnite, and in the calcite above, the latter rarely in tetrahedra up to 2^{mm} in length in cavities in the prehnite and in minute, fresh-looking striated tetrahedra in calcite. Also on botryoidal diabantite and in the "chlorophocite" in Gill.

SPHALERITE.—Rarely in red-brown grains 5–6^{mm} long, fresh-looking and of high luster in the interior, but generally surrounded by a bright red rust layer. In prehnite, epidote and calcite, and in the light gray diabase, filling cavities lined with diabantite, with curious many-faceted globules.

PYRITE appears in minute fresh striated crystals in prehnite and calcite and in limonite pseudomorphs in the same situation.

Also alone, as one of the most modern minerals present, in broad, flattened rosettes in comparatively fresh fissures in the trap.

GALENITE.—Extremely rare in minute grains in prehnite, chlorophœite, and calcite.

QUARTZ.—Only in a single specimen from the Cheapside veins did quartz occur associated with the zeolitic minerals. Here a few minute, elongated prisms appear in and on prehnite. Toward the upper surface of the dyke occur veins 4–5^{cm} wide, coarse comby quartz whose terminations interlace irregularly at the center. Between the wall on one side and the regular cockscomb quartz a layer 10^{mm} thick of broken-up quartz crystals, re-cemented by quartz, showing that the vein had once partly filled itself and then by the rubbing together of the walls the work was interrupted. In other parts of the vein the quartz is much gashed by broad, thin cavities which are often as many as twelve, one above the other, and parallel to the walls as well as scattered in various directions. They seem to have been produced by the repeated formation of a layer of some mineral, now wholly gone, probably selenite or barite. Quartz occurs more abundantly in the veins east of Deerfield than at Cheapside in form of amethyst, agate, carnelian and calcedony, as mentioned by President Hitchcock, and in the main replaces the prehnite of the latter veins.

SELENITE.—Professor Hitchcock mentions that selenite had been found in the Deerfield trap by Professor Silliman (this Jour., vol. v, p. 212), and described moulds of unknown crystals left in the quartz of the zeolitic veins east of Deerfield. Casts taken from these moulds show that the mineral which has disappeared was selenite which occurred here very abundantly and in well-formed crystals 20^{mm} long. The quartz rises into the moulds in sharp parallel crests where it had penetrated between the laminæ of the selenite along the perfect cleavage.

In the Cheapside veins similar, but smaller negative crystals occur in the prehnite which at times rose around and covered the selenite, before its disappearance, forming thus rude pseudomorphs; and I suspect that part or all of the abundant gashing of the prehnite, quartz and datolite may be due to this mineral.

FLUORITE.—Emerald-green dodecahedra-like beads strung upon a satin thread occur half imbedded in and scattered over and among the last-formed fibrous prehnite, the crystals ·03^{mm} in length, also in the same relation to epidote and enclosed in the calcite which succeeds these. In a single case each, emerald-green octahedra and cubo-octahedra, ·03^{mm} in size, in a drusy cavity in epidote, and in green cubes upon prehnite.

CALCITE.—*Of the minerals which succeed to the prehnite*, calcite and datolite are the most important and most abundant and generally replace each other in different veins. In some a large development of calcite occurs with much axinite, in others an equally large development of datolite. The axinite shows that boracic acid was not wanting during the formation of the prehnite and during the subsequent increase of the calcite in the veins where the datolite fails to appear, and the presence of epidote and the more abundant development of prehnite indicate more elevated temperature in the latter, while in the other veins the supply of boracic acid was greatly increased so that nearly all the calcite was absorbed in the formation of datolite.

Excepting quartz all the minerals enumerated above as enclosures in prehnite occur as enclosures in the calcite which follows it, and when pieces where the latter is abundantly developed are thrown in acid and the calcite nearly dissolved away, specimens of great beauty are obtained, the delicate frost-work of prehnite, chalcopyrite, epidote, and the black stout axinite being set off against the brilliant luster of the etched calcite, the whole being sprinkled over with minute pale green dodecahedra of fluor. It occurs abundantly in distinct crystals and drusy surfaces over the prehnite; $-\frac{5}{4}$R small with rounded edges; 1^6 bristling over large surfaces; 1^8, *O*, 4R *i*, 1^3, with curved and striated faces; 1^{12} with deeply striated faces and often distorted; 1^7, $-\frac{1}{2}^6$, the first striated parallel to $-\frac{1}{2}$R, and the form either acuminate or truncated by a single face of R. Other delicately suspended forms had at one end a single broad face of R and rose in a group of sharp scalenohedra at the other end. Every where the crystals were small and affected the most elongate forms with rounded edges and rounded, striated and distorted faces, as if to imitate as closely as possible the prehnite with which they were associated, while on the datolite the forms 2R or -2R, R invariably appear in large perfectly transparent crystals up to 18^{mm} in length, and with a luster equal to that of the datolite itself.

DATOLITE.—The datolite is second only to prehnite in abundance at the new cutting, and surpasses all the minerals occurring here in beauty, perfectly pellucid crystals up to 12^{mm} long being not uncommon, and many of the same showing a great range of rare faces and curious and perplexing distortions. It occurs also in thin veins, developing no crystals on the north side of the river and rarely in the amygdules in the light gray diabase. The mineral fills the veins often completely with a white saccharoidal deposit from 10 to 50^{mm} thick, with only here and there cavities in which fine crystals have come to development. It rests sometimes upon the trap

itself, which is there quite fresh, and where slickensides occur they are of light gray color, due to the mixture of datolite and trap, without the appearance of any of the chloritic or serpentinous products of decomposition which darken the same formation in the prehnite. More commonly it rests upon a thin layer of massive prehnite, rarely with several alternations of datolite and prehnite in calcite or upon the thick layers of spindle-shaped crystals of the former mineral, where the separate attached crystals reach the greatest perfection. The crystals of datolite, which resemble those of Farmington in their glassy clearness and general habit, are remarkable for the great number of faces represented and for the distinctness of the types into which they are grouped, as well as for the manifold and intricate forms produced by the unique development sometimes of single faces and sometimes of all the faces on one side of the vertical plane.

The following is a list of all the forms represented, arranged according to the table given by E. S. Dana,* *ii* (*a*), $i\bar{i}$ (*b*), O (*c*), I (*M*), *i*-2 (o), *i*-3 (*l*), -1-*i* (*u*), $-\frac{4}{3}$-*i* (*v*), -2-*i* (*x*), -6-*i* (*s*), 4-*i* (*H*), 2-*i* (ξ), $\frac{1}{2}\,\dot{i}$ (Ω), 1-$\dot{i}$ (σ), $\frac{4}{3}$-$\dot{i}$ (*t*), 2 $\dot{i}$ (*g*). 4-$\dot{i}$ (*m*), -4 (*w*), 2 (ε), $\frac{4}{3}$ (λ), 1 (μ), $\frac{4}{5}$ ($\varkappa$), -6-3 (*q*), -4-2 (δ). 4 2 (θ), 12 $\frac{3}{2}$ (π), -16-2 (R), -8-2 (β), -4-2 (Q), $-\frac{8}{3}$ 2 (U), -2-2 (γ), 2 2 (a), $\frac{8}{3}$-2 (*i*), 8-2 (*B*), $\frac{8}{5}$-2 (C.) [new], $\frac{8}{5}$-3 (E), $\frac{5}{2}$-3 (F), $\frac{5}{2}$ 5 (K), $\frac{9}{4}$-9 (G).

For convenience of description the crystals may be divided into three types:

I. *The regular.*—In this almost spherical forms are produced by the equal development of a large number of faces. In one crystal *x*, ε, *m* were slightly larger than the rest; *a*, M, *n*, *o*, β, Q, equally developed *c*, *q*, B, very small.

Another very stout, prismatic and resembling the Andreasberg crystals somewhat in the distribution of its faces, except that the elongation in the direction of the clinodiagonal axis was only slight, had the faces *x*, ε, λ, *g*, *m*, largest; *ii*, M, -4, β, Q, O, μ, $i\bar{i}$, about equal; *u*, *v*, *q*, θ, ξ, *o*, π, a, $\varkappa$, smaller.

A third was formed by the nearly equal development of a, *x*, *g*, *m*, ε, λ, μ, M, *o*, *n*, β, B, with O, *s* ($-6i$) *q* and γ subordinate.

A fourth minute but very beautiful crystal was unique for this locality in having the face *o* large and square and *ii* elongated vertically, the faces *g*, *m*, *u*, *x*, a, *n*, M, ε, λ, *o*, β, Q, U, a about equally large, ξ, *q*, μ, *i*, F small.

Several of the larger crystals of this type showed a new face in the zone λ ($\frac{4}{3}$), *g* (2-$\dot{i}$; and *o* (*i* 2), *c* (O) = $\frac{8}{5}$-2 to which I have in the preceding list applied the letter C.

II. *Prismatic type.*—By the great enlargement of *x* and two opposite faces of *m*, a prism of 116° is formed, elongated in

* Tsch. Min. Mitth., 1874, p. 5.

the direction of the axis of the zone x, o, m, the sharp edges of which are beveled by n and o elongated into narrow planes. The other planes are grouped in a very confusing way around the ends of this prism. The uniform dullness of the face x is a characteristic feature.

The crystal under this type which was richest in faces showed the following combination a, b, c, M, o, x, g, m, n, ε, λ, μ, q, β, Q, U, B, a, i; another lacked the faces b, k, and those in the zone B, o, β. Other crystals showed the faces R, π, and τ, in traces.

III. *The tabular type.*—The roughened faces of x are large and nearly circular and approached so as to reduce the crystal to a thick plate, around the edge of which the other faces are placed. The crystals of this type resemble closely the Haytorite pseudomorphs, some of them having the same faces in the same relative development as in the latter, others being even richer in forms than any I have seen described from the Haytor mine.

One crystal contained twenty-eight distinct forms, several only as fine lines, but all capable of quite close measurement. The crystal was peculiar in having the face a (2·2) striated in two directions, forming a series of V's, as is common with the face o from other localities. The latter face is here finely polished. This striation was apparently parallel to the intersection edges which the face a produced would make with o and i-λ. The forms present were a, c, M, o, u, s', Π, ξ, Ω, σ, g, m, n, ε, λ, μ, $\varkappa$, g, θ, β, Q, U, a, B, E, F, K, G. Another crystal of this type went to the extreme of simplicity, being bounded by the faces a, c, M, o, ξ, g, m, n, ε, λ, μ, q, all quite large except q and O, and the face ξ unusually large and shield-shaped.

Similar tabular forms have been recently described from the spheres of chalcedony from Theiss in Tyrol.*

Enclosures in Datolite. *Calcite.*—When the datolite is thrown in acid much calcite is dissolved and a vesicular mass left; and similar pieces are found in the vein itself, showing that the same operation has been performed by natural agencies.

Selenite? Barite?—In the thick veins the minerals are often abundantly gashed by the removal of broad, thin blades of some mineral, possibly selenite or barite, and the surfaces drused over by minute, very distorted crystals of datolite.

Axinite.—Some of the finest crystals of axinite occur in the datolite. The crystals are here sometimes short stout prisms.

Prehnite.—Small portions of prehnite are enclosed rarely in the lower portion of the datolite, also small patches of the chloritic mineral identical with that derived from the decomposition of the former.

* C. Vrba, Zeitsch. Kryst., v, 425.

Sphene.—Very rarely small brown crystals of this mineral appear, resembling exactly the similar occurrence at Bergen Hill.

Tourmaline.—A single minute greenish-brown, hexagonal prism with trihedral termination, which seemed to agree exactly with the sharper one, common in tourmaline, rested upon epidote.

Chalcopyrite.—Small particles of chalcopyrite and pyrite complete the list, the datolite being generally exceptionally free from enclosures.

BOTRYOLITE.—One large cavity of the trap and nearly globular, with vesicular walls, was filled with datolite, which was compact in the vesicles of the trap, above fine granular, like loaf sugar and much gashed, and at the surface coated with a layer of small botryoidal or globular botryolite, which would have been taken for hyalite, if it had not proved fusible with green flame before the blow-pipe.

HEMATITE.—Occurs rarely in extremely minute, flat crystals, blood-red by transmitted light, upon prehnite, and quite abundantly, as the coloring matter of the red diabase.

WAD.—Occurs scattered over much of the prehnite in dots often massed together over a surface otherwise clean, in long diamond shapes, the shadows of elongated calcite scalenohedra which have disappeared.

CUPRITE.—In minute octahedra superficially altered into malachite occurs on datolite and in a single case stains of malachite upon prehnite.

HYALITE.—A colorless hyalite of fine botryoidal structure covers with a thick layer broad surfaces in the dark-gray diabase from the cuttings for the new road from Greenfield to Turner's Falls, where also pearly-white botryoidal layers are very abundant and seem in many cases to be of very recent origin, and to have coated minute rootlets which had penetrated the fissures and lay across the botryoidal surface.

The minerals of the third group, natrolite, stilbite, heulandite, chabazite, analcite and pyrite, associated still with calcite and fluor, appear after the formation of the preceding silicates had ceased entirely, and after much had been removed from the veins by the action of water.

NATROLITE.—This mineral occurs in loose tufts of very minute needles ·01 to ·004^{mm} in diameter, coating prehnite, especially in those specimens where epidote was abundant. It was not found associated with datolite or any of the succeeding minerals. The needles were colorless when fresh, but large pieces of the rock were thickly covered with brown tufts of apparently the same mineral which gave a black bead with the blow-pipe and seemed to be nearly transformed into limonite.

Other groups were shining-black from a coating of an oxide of manganese.

PRODUCTS OF DECOMPOSITION OF NATROLITE. *Saponite.*—In many cases the natrolite has changed peculiarly into saponite. At first the tips of the needles become opaque and crumbling, and this extends to the whole group, and the whole sinks down into small masses from milk-white to straw-color, which are spread over the surface of the prehnite like a thick layer of dried cream with abundant shrinkage-cracks. The hardness is one or less. It gives up only a little iron with hydrochloric, and is quickly decomposed by hot sulphuric acid. A portion introduced into a drop of water falls asunder much like starch —which it every way resembles—with a series of slight explosions which occur at first in rapid succession and continue, growing fainter and farther apart for some little time, until the whole is spread in a broad circle upon the glass. This process exposes minute glassy fragments of prehnite. The flakes after their dispersion present a peculiar appearance under the microscope. The first impression is strikingly that of a slide of nearly dried blood corpuscles of uniform size ·005–·007^{mm}, the single discs being variously attached to each other. Separate groups of discs often simulate closely in shape the grub of the common May beetle. The scales polarize brightly in bluish tints and are indistinguishable from kaolin. In many cases a small mass of the mineral seems to have undergone this vermiculite-like reaction in the vein itself, and a delicate bloom is spread in a circle over the prehnite or epidote surrounding a minute hollow cup of the same white or straw-colored material. In one curious case a minute hollow cube with a side broken in, has a tuft of natrolite needles perched in and around it, these latter having minute dodecahedra of fluor strung upon them as described below. The whole is now transformed into or coated with the saponite, and a delicate bloom of the same coats the surrounding epidote.

It occurs also in hollow pseudomorphs—acute prisms modified by the brachydome and resembling epistilbite.

The natrolite is succeeded in the prehnite-epidote veins only by calcite, acute scalenohedra enclosing whole tufts of the former mineral, and by fluorite, which is speared upon the delicate needles of the natrolite in minute transparent colorless octahedra, pierced through a hexahedral axis. From one to four of these are strung upon a single needle, often at the very tip, and in one field of the microscope (× 40), I counted seventeen; and the whole, having as a background the deep green polished faces of the epidote crystals, upon which the group rested, made an object of great beauty.

THE STILBITE-CHABAZITE VEINS. *Stilbite.*—This occurs

generally in separate, narrow fissures with comparatively fresh walls, associated only with heulandite, chabazite, calcite, pyrite and diabantite, but it is found sometimes resting upon prehnite. It appears (*a*) in circular forms with radiated structure 10–20^{mm} in diameter and up to 2^{mm} thick, either spread separately or aggregated so thickly as to cover the whole surface, or in small hemispheres. Farther south, opposite Deerfield, fine globular forms as large as a marble rest upon the gashed quartz, and secondly (*b*) in small, stout scopiform crystals *i*-$\breve{i}$, *i*-$\bar{i}$, *o*, of dull yellow color. The first form occurs associated with calcite, and rarely chabazite. The second with heulandite and chabazite, and I examined a flat surface of the trap, four feet square, one-half of which was covered with radiated stilbite, at first thickly covering the surface, then separating into distinct discs, and then quite suddenly replaced by heulandite with which was associated chabazite, and rarely the small prismatic crystals of stilbite. A third form of stilbite (*c*) is in interlaced crystals, 4^{mm} long, perfectly pellucid, with even, highly-polished faces *i*-*i*, *i*-$\breve{i}$, *o*. Under the microscope the mineral shows a fine, rigid lining parallel to *o* which seems to mark lines of growth, and has no effect upon the polarization. At right angles to this run (*a*) long lines of flat water cavities, often negative forms in whole or part, or such forms many times repeated and indicating quite rapid crystallization, and (*b*) sharply marked lines of multiple twinning, the whole crystal being made up of fine plates which increase in number from below upward, new plates being intercalated and old ones obliterated as in a compound coral. The new plates sometimes appear as points and increase upward with curved faces, and sometimes the old crystal develops a P-face upon which the new one is based.

Products of the decomposition of stilbite. *Kaolin (?).*—Many broad surfaces of the trap are covered with snow-white stellate patches of stilbite which show all stages of the decomposition of the mineral into kaolin (?). In specimens already become snow-white and opaque the kaolin can be seen under the microscope in minute rounded scales and aggregations of these into beaded lines which are crowded between the laminæ of the stilbite, the latter showing no signs of change but remaining limpid and polarizing apparently as vividly as in the freshest specimen. In other pieces where the change is nearly complete the mass shows only aggregate polarization, and only traces of the stilbite remain.

Heulandite.—This mineral occurs quite abundantly at the new cutting in small, stout prisms, $i\,\bar{i}$, $2\,i$, $\text{-}2\,i$ up to 2^{mm} in length with sharp edges and no indication of other faces. It is almost always coated with a thin varnish of limonite, while the

chabazite and stilbite, associated with it, show entirely fresh faces. It is the lincolnite of President Hitchcock, and the specimens studied by me agree exactly with those labeled lincolnite by him, and coming from the old locality east of Deerfield. The mineral collection at Amherst contained a few crystals, also identical with the above, from the Fitchburg cutting, and these were separated by Professor Shepard from heulandite under the name lincolnite.*

After careful study I find all these crystals identical with each other and with heulandite, both optically and crystallographically.

ANALCITE.—Occurred (*a*) in a single crystal upon prehnite; (*b*) in flat eight-sided plates 10–12^{mm} across, striated and formed by the growth of the trapezohedron, in a narrow fissure; (*c*) in milk-white films circular and octagonal, 5–10^{mm} across; (*d*) in extremely fine botryoidal surfaces with crystalline structure, with here and there a system of curious concentric depressed rings, like the siliceous annulations on some fossils (Beckite). They are as if formed by pressing several rings each smaller than the other into a soft mass, so that it should rise as a series of thin concentric combs between them, (*e*). Other pieces which seem to me to have been analcite of the form (*b*) are now wholly decomposed into a yellow ferruginous kaolin (?).

Associated with the analcite (*b*) and resting against the separate crystals on all sides is opaque white calcite, $\frac{5}{4}R$ and 1°, grouped in parallel clusters, the faces all rounded and the clusters looking as if they had been made of some soft material which had "run." This grouping of the calcite around the separate crystals of the analcite may explain the annulations mentioned above, the two minerals having increased alternately and the calcite afterward having been removed.

CHABAZITE.—At Cheapside it occurs in small pellucid rhombohedra with delicately striated faces. Crystals 1^{mm} in length. It rests always upon the trap and never upon the heulandite with which it is associated, though when they come in contact the latter penetrates the chabazite and is the older mineral.

Farther south, east of Old Deerfield, it occurs in the same association. Most of the specimens agree in all respects with those already described but are whitened and opaque from incipient decomposition. Rarely much larger crystals occur which are 6–8^{mm} in length. These are quite fresh, the faces of good luster but faceted in a very intricate manner, indicating that the twinning by which the apparent rhombohedra are

* C. U. Shepard, Catalogue of Minerals found within 75 miles of Amherst College. Amherst, 1876.

built up has reached here an unusual complexity. The crystals are commonly twinned on *O*, and in three cases very perfect twins, composition face *R*, occur, both halves being developed to perfect rhombohedra. In a single instance the apex of a crystal is replaced by three large deeply striated faces of a flatter rhombohedron apparently $\frac{1}{2}$. The striæ run parallel to the combination edge of *R* and $\frac{1}{2}$ and are plainly formed by the oscillatory combination of $\frac{1}{2}$ and *O*. The character of the face did not allow accurate measurement. In thin fissures it encrusts broad areas producing a tessellated surface made up of a great number of flattened crystals showing each a single face of *R*, the adjacent ones being in twin position and the whole reflecting the light together like a single face of a very large crystal.

The paragenesis of the stilbite-chabazite veins is—

1. Radiated stilbite.
2. Chabazite.
3. Calcite.
4. Pyrite; or

1. Prehnite.
2. Heulandite.
3. Prismatic stilbite.
4. Chabazite.
5. Calcite.

Below is a general table of the paragenesis of the minerals found. The oldest is first, and the overlap of the words corresponds approximately to the overlap of the minerals.

Minerals produced at elevated temperature.
- Diabantite.
- Albite.
- Prehnite.
- Epidote.
- Axinite.
- Tourmaline.
- Calcite.
- Fluor.
- Sulphides.
- Datolite.
- Sphene.
- Calcite.
- Sulphides.

At ordinary temperature.
- Natrolite.
- Stilbite.
- Heulandite.
- Analcite.
- Calcite.
- Fluor.
- Sulphides.
- Chabazite.
- Calcite.
- Fluor.
- Pyrite.

Products of decomposition.
- Saponite.
- Chlorophæite.
- Kaolin
- Malachite.
- Limonite.
- Wad.

ART. XL.—*Notice of the remarkable Marine Fauna occupying the outer banks off the Southern Coast of New England, No. 7, and of some additions to the Fauna of Vineyard Sound;* by A. E. VERRILL. (Brief Contributions to Zoology from the Museum of Yale College: No. LIII.)

[Published by permission of Professor S. F. Baird, U. S. Commissioner of Fish and Fisheries.]

DURING the present season, as in 1881, the headquarters of the U. S. Fish Commission were at Wood's Holl, Mass. The organization of the party was nearly the same as last year.* The special object, this year, was to continue the exploration of the sea-bottom, and its fauna beneath the edge of the Gulf Stream, which had been so successfully carried on during the two previous seasons. Owing to the unusual delay of the government appropriations, our work was delayed about a month, in the best part of the season, for we could not begin our dredging until August. Unfavorable weather and other causes afterward prevented us from making more than five trips to the Gulf Stream slope this year. But these were very successful.

One trip, occupying three days, was also made to the region east of Cape Cod. On this trip very cold bottom-water was found at moderate depths. It extended southward the known range of a number of northern species, previously unknown on this part of our coast, but did not reveal any new forms. Among the species of most interest taken on this occasion, are the following: several examples of *Urticina multicornis* V. (of which only one specimen was known previously), 55 to 90 fathoms; *Porania spinulosa* V., large, 90 fath., sta. 1088; *Solaster endeca* F., many, large and small, 32 to 90 fath.; *Hippasteria phrygiana* Ag., several, large, 34 to 90 fath.; *Astrophyton Agassizii* St., many, 55 to 61 fath., off Chatham, sta. 1078, 1079; *Pentacta frondosa*, large, 34 to 37 fath.; *Pandalus borealis*, 90 to 110 fath.; *Geryon quinquedens*, 110 fath.; *Balanus Hameri*, 33 fath.; *Rossia Hyatti*, several, large, 44 to 90 fath.

Of the five Gulf Stream trips, one was made southeastward

* The scientific party, associated with the writer in carrying on the dredging operations and making the collections, this year, consisted of Mr. Richard Rathbun; Mr. Sanderson Smith; Mr. J. H. Emerton (as artist); Professor L. R. Lee; Mr. B. F. Koons; Mr. H. L. Bruner; Professor Edwin Linton. Professor S. I. Smith was with us for a few days. Mr. Peter Parker and R. H. Miner, midshipmen, U. S. N., took charge of the fishes. John B. Blish, midshipman, U. S. N., kept the records of soundings and temperatures, and Capt. H. C. Chester had charge of the dredging apparatus, as in previous years. The dredgings were all made by the "Fish Hawk," commanded by Lieut. Z. L. Tanner, U. S. N., as during the two previous years. The writer, as usual, had general charge of these explorations, and of the investigation of the invertebrate fauna.

from Nantucket, farther east than any of those of 1880 and 1881, while another was made to the region about 100 miles south of the eastern end of Long Island, farther west than any of the former ones; the other three were in the intermediate region, off Martha's Vineyard. Our dredgings, in this region, therefore, now cover a belt about 150 miles, east and west, mostly between the 100 and 600 fathom lines. The total number of successful hauls made along this belt, in more than 100 fathoms, is now over one hundred. These have nearly all been made with the large improved trawls; a few have also been made with a large rake-dredge. Probably no other part of the ocean-basin, in similar depths, has been more fully examined than this region.

The total number of species of Invertebrata, already on our lists of the fauna of this belt, is about 575. This number includes neither the Foraminifera, nor the Entomostraca, which are numerous, and but few of the sponges. Probably the total list of Invertebrata, already obtained, when completed will include not less than 700 species. Of these less than one-half were known on our coast before 1880. Of fishes, there are, perhaps, 75 species. Of the whole number, already determined, about 265 are Mollusca, including 14 Cephalopoda; 85 are Crustacea; 60 are Echinodermata; 35 are Anthozoa; 65 are Annelida.

The Steamer "Fish Hawk," with which we have explored this region during the past three seasons, was built particularly for use in the hatching of shad eggs, in the mouths of shallow rivers, and is, therefore, not adapted for service at sea, unless in very fine weather. A much larger steamer, the "Albatross," of 1000 tons, has been built for the use of the Fish Commission, and is now being fitted up expressly for deep-sea service, for which she will be, in every respect, well adapted, and will have the best equipment possible for all such investigations, and at all depths. The examination of the bottom beyond the depth of about 600 fathoms has, therefore, been deferred by us till the completion of the "Albatross." Nevertheless the apparatus that we have used on the "Fish Hawk" has been better, in some respects, than most other vessels engaged in such work have had, whether American or foreign. This year several new improvements have been made, especially in the deep-sea thermometers. New forms of traps for capturing bottom animals have also been devised. The "*trawl-wings*," first introduced by us last year, have been used this year with great success, for they have brought up numerous free-swimming forms, from close to the bottom, which could not otherwise have been taken. The use of steel wire for sounding, and of wire rope for dredging, has enabled us to obtain a much greater

number of dredgings* and temperature observations than would have been possible, under the old system, adopted on the "Challenger."

Of Echinoderms, nearly all of the species previously enumerated from this region and several additional ones were obtained. Among those of special interest were *Goniocidaris papillata*, 156 to 158 fath.; *Brissopsis lyrifera*, 158 to 194 fath.; *Spatangus purpureus*, 89 to 158 fath.; *Schizaster canaliferus*, 100 fath., several; *Echinus Wallisi* A. Ag., 640 fath.; *E. gracilis*, numerous and of large size at stations 1097 and 1098, in 156 to 158 fath.; *Phormosoma Sigsbei* A. Ag., station 1123, in about 700 fathoms,† several, both large and small, the largest 124mm in diameter; *Porania grandis* V., abundant in 156 to 158 fath.; *Odontaster hispidus* V., abundant in 89 fathoms.

Among those added to the fauna this year are a *Diadema-like* sea-urchin; *Solaster Earllii* V., of which a large nine-armed specimen, bright scarlet in color, was obtained in 234 fath., sta. 1121; *Lophaster furcifer*, several from 234 and 640 fath.; *Astrogonium granulare*, from 156 and 640 fath.; *Astrophyton Lamarckii*, color bright orange, several from 194 fath. *Asteronyx Loveni* M. & Tr., sta. 1123, in about 700 fath., on a pennatulid, color bright orange; *Ophioscolex*, new sp., with four arm-spines, and a small tentacle-scale, 234 fath.; *Rhizocrinus Lofotensis*, young, from 640 fath.

Most of the Anthozoa of the previous years were again obtained, with some additional ones, including a remarkable new Pennatulid belonging to a new genus,‡ and two Gorgonians;

* As an illustration of the rapidity with which this work has been done, by employing persons skilled in the various operations, and using the wire rope, reeled upon a large drum, I give here a memorandum of the time required to make a very successful haul. In 640 fathoms, at station 1124, the large trawl was put over at 4:29 P. M.; it was on the bottom at 4:44, with 830 fathoms of rope out; commenced heaving in at 5:17; it was on deck at 5:44 P. M.; total time for the haul, 1 hour, 15 minutes. The net contained several barrels of specimens, including a great number and large variety of fishes, as well as of all classes of invertebrata, probably more than 150 species altogether, several of them new.

At station 1125, in 291 fathoms, the trawl was put over at 6:03 P. M.; on bottom at 6:10, with 500 fathoms of rope out; commenced heaving in at 6:32; on deck at 6:50; total time 47 minutes. This was a very good haul, but not so large as 1124. This was the seventh successful haul of the trawl made that day. All the specimens were assorted, labelled and packed away in alcohol, before 9 P. M.

† The trawl was put down, at this station, in 780 fathoms, but before it was taken up the depth had become 627 fathoms.

‡ *Distichoptilum* V., gen. nov. Slender pennatulids, with an axis through the whole length, and polyps arranged alternately, in a simple row, on each side; calicles bilobed, appressed; zooids three to each polyp, one in front and one on each side of each cell; spicula abundant in the calicles, rachis, and stalk.

Distichoptilum gracile V., sp. nov. Long and slender, with a long stalk. Polyp-calicles, rather large, rigid, closely appressed, with two sharp terminal lobes, filled with spicula, concealing the opening, and overlapping the base of the calicle in front; zooids small, not exsert, showing as small white spots at each side and in front of each polyp cell; stalk long, slender, with a long narrow bulb; color bright orange-red, due to the spicula; end of bulb yellowish; length, 18 inches, or 456mm; breadth in middle, 2mm; length of stalk, 100mm.

List of off-shore Stations occupied by the Fish Hawk in 1882, *to Sept.* 8.

Stat.	Locality.	Fath.	Bottom.	Date.	Temp. F. Bottom.	Temp. F. Surface.	Hour.
	Off Cape Cod.			Aug.			
1078	Nauset Beacon, NW ¼ N, 10 m.	55	fine sandy mud	2	37°	63°	7.30 A. M.
1079	" NW by W ½ W, 8¼ m.	61½	fine sand	2	37	63·5	8.40 "
1080	" NW by W ½ W, 6½ m.	55	fine sand	2	37	61·5	9.40 "
1081	" W by S, 5½ m.	33½	gravel and pebbles	2	39	59	10.50 "
1082	Cape Cod Lt., NW ¾ N, 11½ m.	28	coarse gravel	2	40	59	11.45 "
1083	" W by N, 15 m.	83½	--------	2	38	64	12.45 P. M.
1084	" WNW ⅝ W, 8 m.	37½	coarse sand	2	38	62·5	2.30 "
1085	Race Point, S 33° E, 2 m.	34½	fine sandy mud	3	39	64	6.15 A. M.
1086	" S 20° W, 2¾ m.	34	fine sand	3	39·5	64	7.00 "
1087	Cape Cod Lt., SSW, 7 m.	44	gray sand	3	39	62·5	8.30 "
1088	" SW ¾ W, 9½ m.	90	coarse sand	3	38	62	9.50 "
1089	" SW ¾ W, 14 m.	110	gray mud	3	38·5	63	10.10 "
1090	" SW ¾ W, 13¾ m.	110	gray mud	3	38·5	62	11.50 "
	Off Martha's Vineyard.						
	N. Lat. W. Long.						
1091	40° 03′ 00″; 69° 44′ 00″	65	gray sand, shells	11	46	75	5.30 "
1092	39 58 00; 69 42 00	202	gray sand	11	41	75	6.54 "
1093	39 56 00; 69 45 00	349	sandy blue mud	11	40	75	8.35 "
1094	39 57 00; 69 47 00	301	blue mud	11	40	76	10.10 "
1095	39 55 28; 69 47 00	321	soft green mud	11	40	76	11.55 "
1096	39 53 00; 69 47 00	317	green mud	11	40	75·5	1.39 P. M.
1097	39 54 00; 69 44 00	158	fine sand	11	45	75·5	3.10 "
1098	39 53 00; 69 43 00	156	fine sand	11	43·5	75	4.35 "
1107	40 02 00; 70 35 00	116	gray mud	22	48	71	6.00 A. M.
1108	40 02 00; 70 37 30	101	fine sandy gray mud	22	48	71	6.55 "
1109	40 03 00; 70 38 00	89	gray mud	22	49	71	7.55 "
1110	40 02 00; 70 35 00	100	fine sandy gray mud	22	47	72	9.10 "
1111	40 01 33; 70 35 00	124	fine sand	22	47	72	10.45 "
1112	39 56 00; 70 35 00	245	green sandy mud	22	43	72	12.43 P. M.
1113	39 57 00; 70 37 00	192	green mud	22	43	72	1.45 "
1114	39 58 00; 70 38 00	171	green mud	22	43	72	2.40 "
1115	39 59 00; 70 41 00	146	green sandy mud	22	45	72·5	3.28 "
1116	39 59 00; 70 44 00	144	hard sandy mud	22	46	72	4.20 "
1117	40 02 00; 70 45 00	89	fine sand	22	48	72	5.30 "
1118	40 03 00; 70 45 00	70	fine sand	22	49	72	6.20 "
	Off Nantucket, S.S.E.						
1119	40° 08′ 00″; 68° 45′ 00″	97	sand, shells	26	48	65	6.32 A. M.
1120	40 05 00; 68 48 00	194	fine sand, stones	26	43·5	65	7.41 "
1121	40 04 00; 68 49 00	234	fine s'nd, foss. stones	26	41·5	65	9.05 "
1122	40 02 00; 68 50 00	351	sand and stones	26	40·5	67	10.28 "
1123	39 59 45; 68 54 00	780	green sandy mud	26	39	69	12.00 M.
1124	40 01 00; 68 54 00	640	fine s'nd, foss. stones	26	39	65	4.01 P. M.
1125	40 03 00; 68 56 00	291	sandy mud	26	40	64	5.45 "
	Off Block Island, S.			Sep.			
1137	39° 40′ 00″; 71° 52′ 00″	173	fine sand	8	46	70	6.00 A. M.
1138	39 39 00; 71 54 00	168	fine soft sand	8	46	71	7.24 "
1139	39 37 00; 71 55 00	291	sandy mud	8	44	72	8.48 "
1140	39 34 00; 71 56 00	374	sandy mud, gr'vel, peb.	8	40	73	10.35 "
1141	39 32 00; 71 57 00	389	sandy mud	8	40	74	12.27 P. M.
1142	39 32 00; 72 00 00	322	fine sandy mud, peb.	8	41	74	1.52 "
1143	39 29 00; 72 01 00	452	sandy mud	8	40	74	3.36 "
1144	39 31 00; 72 06 00	386	soft sandy mud	8	41	74	6.00 "

Acanthogorgia armata V., 640 fath., and *Paramuricea borealis* V., from 234 fath.; the former, when living, was bright orange; the latter was pale salmon. Of those previously taken, one of the most interesting was *Pennatula borealis*, obtained in 192, 317 and 640 fath. The largest one, from 317 fath., was 21·5 inches high and 5·25 broad.

Of Pycnogonida, we took some large and interesting forms, including two examples of *Colossendeis colossea* Wilson, station 1123, in about 700 fath., of which the larger was 19·5 inches across; *C. macerrima* W., from 317 fath.; and several of *Nymphon Strömii*, from 234 to 640 fath.

Crustacea* were much less abundant than in previous years, but large numbers of large shrimp, *Pandalus leptocerus* and *P. propinquus* occurred, the latter inhabiting the deeper waters, 158 to 640 fath. *Cancer borealis* was frequent in 90 to 194 fath. Among the more interesting species were *Geryon quinquedens*, taken in considerable numbers and of large size, at stations 1140 to 1143, in 322 to 452 fath.; *Lithodes maia*, at station 1125, in 291 fath.; *Pentacheles sculptus* Smith, one large, at station 1140, in 374 fath.; *Ceraphilus Agassizii* S., several times, in 291 to 640 fath.; *Sabinea princeps* S., stations 1140 and 1143, in 374 to 452 fath.; *Boreomysis tridens*, in 351 fath.; *Hippolyte Liljeborgii*, frequent in 144 to 640 fath.; *Janira spinosa* Harger, in 640 fath.; *Astacilla granulata* (Sars) H., in 291 to 640 fath.

Many of the other species formerly taken also occurred. Several new species were also added to the fauna; among these are two fine species allied to *Munida*.

Of Cephalopods, besides the usual forms, we took one new species,† belonging to the genus *Abralia* of Gray, a genus not known from the American coast before. A *living* specimen of the *Argonauta argo* was caught in a dip-net, while swimming at

* The Crustacea of 1880 were enumerated and described by Prof. S. I. Smith, in Proc. Nat. Mus., iii, pp. 413–452, 1880: some of those of 1881 are included by him in his report on the "Blake Crustacea," Bulletin Mus. Comp. Zool., pp. 1–108, (16 plates), June, 1882. The more difficult species, here enumerated, have been identified by Professor Smith.

† *Abralia megalops*, sp. nov. Small, eyes large; caudal fin, about two-thirds as long as the mantle, and much broader than long, transversely elliptical; 2d and 3d pairs of arms equal; dorsal a little shorter; ventrals shortest. Sessile arms with two rows of hooks, which are replaced by small suckers on the distal third; tentacular clubs with two alternating rows of hooks, and with marginal suckers distally, on each side, alternating with the median hooks, and with proximal and terminal groups of smaller suckers. Color pale, with numerous small dark brown chromatophores above, larger and more crowded on the head and bases of arms; lower side with several larger, round, symmetrically placed, purplish brown spots and with minute ones between them. Length of mantle, 15^{mm}; diameter of body, 7^{mm}; length of fin, 11^{mm}; breadth across fins, 18^{mm}; breadth of head, 7^{mm}; diameter of eye, 4·5^{mm}; length of dorsal arms, 13^{mm}; length of second pair, 14^{mm}; of third pair, 14^{mm}; of tentacular arms, 25^{mm}; of ventral arms, 10^{mm}. Probably this specimen is young. Described from alcohol.

the surface, by Dr. Kite, surgeon. This was taken about 100 miles south of the eastern end of Long Island. We took a fine large specimen of *Eledone verrucosa* V., in about 700 fathoms (sta. 1123); and the second known example of the large *Rossia megaptera* V., in 640 fathoms (sta. 1124), the first one having been taken from a halibut's stomach, at the Grand Banks.

Several shells were added to our lists, some of them of special interest. Among these is a fine new species of *Trophon*,* from 70 fathoms, and four species of Chitonidæ, of which one from 640 fathoms, represents an Australian genus, *Placophora*,† not before known in the Atlantic. The other three are *Hanleyia mendicaria*, 317 fathoms; *Leptochiton alveolus*, in 291 and 640 fathoms; and what appears to be the true *Trachydermon exaratus* (G. O. Sars) in 194 fathoms. *Choristes elegans* was again found in old skates' eggs, in 640 fathoms, and in the same situation we found *Cocculina Beanii* and *Addisonia paradoxa* Dall. The latter was taken several times, in 89 to 640 fathoms. A fine living specimen of *Dolium Bairdii* was taken in 192 fathoms. Two living specimens of *Mytilimeria flexuosa*‡ occurred in 349 fathoms, associated with *Pecchiolia gemma* V., also living;

* *Trophon Lintoni* Verrill & Smith. Shell stout, rough, with six very convex, somewhat shouldered whorls, crossed by about nine very prominent, thick, obtuse ribs; whole surface covered with strong, elevated, obtuse, scaly, revolving cinguli, usually alternately larger and smaller, separated by narrow, deep grooves; they are crossed by arched scales or lines of growth. Aperture broad; canal short, narrow, a little curved; umbilical pit distinct, but small. Length, 28^{mm}; breadth 17^{mm}; length of canal and body-whorl, 19^{mm}; length of aperture, 15·5^{mm}; its breadth, 7·5^{mm}. Station 1118. Named in honor of Professor E. Linton, of our party.

† *Placophora* (*Euplacophora*) *Atlantica* V. & Smith. Broad ovate, with the marginal membrane very broadly expanded in front, and covered with fine spinules, above and below, distinctly radially grooved beneath, and with intermediate rows of small verrucæ. Edge of mantle, in front of head, digitately divided into about seven lobes, the anterior ones slender, acute. Gills about 16 on each side, occupying more than two-thirds the length of the foot. Shell, broad-ovate, with short, broad anterior valves, the posterior one very small, lunate, and a little emarginate at the posterior edge; anterior one very broadly rounded, short, hind edge with a slight rounded median notch, surface uniformly granulous and faintly radially grooved; inserted edge narrow, with about 30 irregular denticles; middle valves have a slight median beak at the hind edge, their lateral areas are strongly marked, crossed with diagonal rows of low, rounded granules, separated by narrow radial grooves; central areas with smaller and less distinct granules, and transverse lines of growth. Color, rusty brown. The largest example is, in alcohol, 32^{mm} long; breadth, 26^{mm}; length of shell, 21^{mm}; breadth of shell, 18^{mm}; length of anterior valve, 4^{mm}; breadth, 15·5^{mm}.

I am indebted to Mr. W. H. Dall for the generic determination of this species.

‡ The animal of this shell, in alcohol, has a small and short anal tube, surrounded by small papillæ, and a very much larger incurrent orifice, occupying a ventral position, and surrounded by numerous long and large tentacle-like papillæ; the orifice for the foot is small; the edge of the mantle is bordered by very small papillæ. There is a slender, translucent byssus. The hinge-ligament is strengthened by a distinct ossicle, placed lengthwise, more or less ovate in form, with the smaller end next the hinge-teeth, and somewhat truncated.

Pecchiolia gemma also has an ossicle, similarly placed, with the posterior end broader and notched in the middle, the narrower end truncated.

a fresh valve of *Pholadomya arata*, in 108 fathoms; *Axinopsis orbiculata* G. O. Sars, in 202 fathoms; *Modiolaria polita* V. & S., in 321 fathoms. In trawl-wings, station 1141, 389 fathoms, we took four examples of *Clione papilionacea* Pallas, associated with a lving specimen of *Cavolina longirostris.*

The southern species of Pteropods were comparatively scarce this season, and the very large species of *Salpa*, so abundant hitherto, was only met with once, this year, but the small species (*S. Caboti*) occurred in large numbers, and with it several very brilliant species of *Saphirina* were taken.

Evidence of great destruction of life last winter.

One of the most peculiar facts, connected with our dredging this season, was the scarcity or total absence of many of the species, especially of Crustacea, that were taken in the two previous seasons, in essentially the same localities and depths, in vast numbers,—several thousands at a time. Among such species were *Euprognatha rastellifera*, *Catapagurus socialis*, *Pontophilus brevirostris*, and a species of *Munida.* The latter, which was one of the most abundant of all the Crustacea, last year, was not seen at all this season. An attempt to catch the "tile-fish" (*Lopholatilus*) by means of a long trawl-line, on essentially the same ground where eighty were caught, on one occasion, last year, resulted in a total failure this year. It is probable, therefore, that the finding of vast numbers of dead tile-fishes floating at the surface, in this region, last winter, as was reported by many vessels, was connected with a wholesale destruction of the life at the bottom, along the shallower part of this belt (in 70 to 150 fathoms), where the southern forms of life and higher temperatures (48° to 50°) are found. This great destruction of life was probably caused by a very severe storm that occurred in this region, at that time, which, by agitating the bottom-water, forced outward the very cold water that, even in summer, occupies the great area of shallower sea, in less than 60 fathoms, along the coast, and thus caused a sudden lowering of the temperature along this narrow *warm zone* where the tile-fish and the crustacea referred to were formerly found.

As the warm belt is here narrow, even in summer, and is not only bordered on its inner edge, but is also underlaid by much colder water, it is evident that even a moderate agitation and mixing up of the warm and cold water might, in winter, reduce the temperature so much as to practically obliterate the warm belt, at the bottom. But a severe storm, such as the one referred to, might even cause such a variation in the position and flow of the tidal and other currents as to cause a direct flow of the cold inshore waters to temporarily occupy this area, pushing outward the Gulf Stream water. The result would be

the same, in either case, and could not fail to be destructive to such species as find here nearly their extreme northern limits.

In order to test this question more fully, Professor Baird also employed a fishing vessel, the "Josie Reeves," to go to the grounds and fish systematically and extensively for the tile-fish. On her first trip, ending September 25, she did not find any "tile-fish," but took another food-fish (*Scorpæna dactyloptera*), known on the European coast, and first taken by us, in 1880.

Additions to the fauna of Vineyard Sound; Surface dredgings.

During the intervals between the Gulf-Stream trips, shore collecting and a large amount of surface dredging, both by day and night, were done in the vicinity of Wood's Holl, by means of the two steam launches belonging to the Fish Commission. In the surface-dredging, Mr. Emerton took the most active part. The surface work was very productive this season, not only affording a vast number of larval forms of Crustacea, Echinodermata, Annelida, Mollusca, etc., but also a large number of adult Annelida, belonging to the Syllidæ and various other families, including a number of very interesting new species. Certain species of *Autolytus* were unusually abundant. Many thousands of specimens of *A. varians* V. (formerly *A. ornatus* V.) were often taken in a single evening, the males of both the red and green varieties being far more numerous than the females, which were always bright red, when containing eggs. The males of a much larger species, the *A. ornatus* (*Proceræa ornata* V., 1873, stem-form), were also abundant; the much larger females, which are transversely banded with red, were taken in smaller numbers. A small, but very remarkable, new species (*A. mirabilis*),* first discovered

* *Autolytus mirabilis* V., Trans. Conn. Acad., iv, pl. 13, figs. 8–10. Stem-form long and slender. Antennæ, tentacular cirri, first pair dorsal cirri, and caudal cirri very long and slender, 4–6 times the breadth of the body; median antenna and first dorsal cirrus longest; second dorsal cirri twice the breadth of body; others varying in length, but mostly longer than breadth of body; two long, narrow epaulets, extending from the head back to third body-segment. Stomach large, oblong; pharynx slender, with one flexure, denticulate at the end. The most anterior formation of the sexual young takes place behind the fiftieth segment; in one individual (see fig. 8, loc. cit.) six female individuals follow one another, the largest one being nearly ready to separate, and having 22 segments, with a well developed head, four eyes, and long antennæ. Some detached females, bearing eggs, have, however, no more than 16 to 20 segments.

Vineyard Sd. and off Gay Head, 4 to 8 fath., among hydroids, 1881 and 1882.

Female: Small, with only one pair of slender cirri, longer than breadth of head, on the buccal segment; two anterior body-segments with only short setæ; capillary setæ begin on the third segment; two pairs of eyes close together, the anterior larger; three antennæ nearly equal, long and slender, three or four times the breadth of the head; caudal cirri, when fully developed, about as long as the antennæ; dorsal cirri slender, longer than breadth of body. Length, 3 to 3·5^{mm}. Color, when containing eggs, dark olive-brown; after eggs are laid, pale greenish;

by us in 1881, was not uncommon, but only the females were taken at the surface. The stem-form occurred among hydroids and ascidians at moderate depths. This species is remarkable for the large number of sexual individuals that may be developing, simultaneously, from the stem-form. It is not uncommon to find it carrying five or six sexual individuals, in various stages, one behind another.

A very singular Syllidian,* of which only the sexual forms are known, was taken several times at the surface, in the evening. We also took these in 1880 and 1881. They have probably been detached from a very different stem-form. The genus is allied to *Chætosyllis* Mgn., but the head is entirely destitute of antennæ. It has four large eyes and swims very actively.

Odontosyllis lucifera V., of both sexes, was very common in the surface nets all through August and to Sept. 15th, but mainly in the evening. With the latter a smaller and more delicate species usually occurred, but in less abundance. This belongs to the genus *Eusyllis*† and has been known to me for a number of years.

eyes dark brown. Wood's Holl, surface, evening, Aug. 2 to Sept. 18, 1882; off Gay Head, with the stem-form, 1881. Description from life.

* *Tetraglene* Grube, 1863. Sexual forms: Head distinct, with four large eyes, but with no other appendages. Segments behind the head similar, all bearing large parapodia, with long setæ, a long dorsal cirrus, and a smaller slender ventral cirrus. Caudal cirri two, long, sub-moniliform.

Tetraglene agilis V., sp. nov. Trans. Conn. Acad., iv, pl. 25, fig. 10. Rather large and stout, head broader than long, subtruncate, or even emarginate in front, constricted abruptly behind; eyes large with front lens round, the two pairs near together, the anterior a little larger and wider apart. Body-segments separated by deep constrictions; parapodia with large setigerous lobe, as long as the breadth of the segments; setæ numerous, longer than the parapodia, the shorter ones with a long, slender article; capillary setæ begin on the third segment; cirri more or less moniliform, slender, tapered, about four times as long as the breadth of the head; caudal cirri similar to dorsal; ventral cirri slender, smooth. Color of males, yellowish white; of females, pale orange-yellow or salmon; eyes brown; eggs reddish, laid Aug. 5, 1882. Length of largest (♀) about 25^{mm}; males about 20^{mm}. Taken in the evening, at the surface, near Nomansland, Sept., 1880; Wood's Holl, Aug. 4, 1881, and from Aug. 5 to Sept. 12, 1882. Description from life.

† *Eusyllis tenera* Verrill, Trans. Conn. Acad., iv., pl. 13, fig. 12; pl. 14, figs. 4, *a*, *b*. Slender, 5 to 7^{mm} long, with very long, slender antennæ and cirri, which are often curled in spirals, and irregularly transversely constricted, smoothish in full extension. Pharynx short, straight, with a large, sharp median tooth at the extreme anterior end; the edge of the tube is divided into numerous (about 30) small, sharp denticles, becoming obsolete on the lower side; sheath of pharynx with a circle of larger, soft papillæ (about 13) in front of the tube. Stomach large, oblong; intestine with a pair of short, rounded, lateral pouches at the end of the stomach. The median antenna and upper tentacular cirri are 3 to 6 times as long as the breadth of the body; lateral antennæ and lower tentacular cirri shorter; the longest dorsal cirri are 5 to 6 times as long as breadth of body; shorter dorsal cirri alternate irregularly with the long ones. The palpi are very flexible and changeable in form, prominent, flattened, tapered or oblong, obtuse. Head rounded in front, widest in front of the middle, opposite the largest eyes. Eyes six; four larger ones nearly equal, the anterior a little larger and wider apart, near the sides of the head; the minute frontal eyes are near the inner bases of

Another interesting new species, which was taken at the surface, both this year and last, appears to belong to the genus *Syllides.** Among the less common forms of Syllidæ were

the antennæ. Setæ with an oblong, blade-shaped terminal article, obtuse and slightly bidentate at tip.

Sexual individuals have, also, fascicles of long capillary setæ, beginning on the fourteenth setigerous segment.

Color translucent bluish white, pinkish or purplish brown anteriorly, and more or less purplish brown or blue-gray on the sides of the body and more decidedly on the bases of the parapodia; cirri white; pharynx and stomach pale brown; intestine brown or olive-green, constricted between the segments; eggs showing through, purplish brown; eyes dark red.

New Haven to Vineyard Sound; frequent at surface in evening, at Wood's Holl, from Aug. 2 to Sept. 15, 1881, 1882. Also dredged in Vineyard Sd., in 8–12 fath., among bryozoa and *Amœrœcium pellucidum*. Allied to *Syllis fragilis* Webs., which probably also belongs to *Eusyllis*. Described from life.

* *Syllides setosa* V., sp. nov. Trans. Conn. Acad., pl. 24, figs. 11, 11*c*. Body not very slender, with about 50 segments and large parapodia. Head changeable, usually short, obtusely rounded or subtruncate in front, rounded laterally, closely united to buccal segment. Palpi short, often not visible from above; below they appear as flat lobes. Eyes six; two median ones largest, close to sides of head; posterior ones a little smaller and nearer together, and close to the others; front ones very small, close to the outer bases of the palpi. The antennæ and four tentacular cirri are all similar in size, form and color, but the odd antenna is a little the longest (about three times breadth of head), and the tentacular cirri are usually somewhat shorter than the lateral antennæ (or about twice the breadth of the head); all are contractile and somewhat changeable in form; usually they are distinctly clavate, with narrow bases and obtuse, swollen, transversely wrinkled tips. Anterior dorsal cirri long, slender, usually more or less clavate, with a distinct basal joint and numerous annulations, becoming more marked distally; they are as long as the antennæ, or longer, and about three times the breadth of the segments; they often increase in length on the first few segments, but are apt to vary irregularly; the longest are more than four times as long as the breadth of the segments. The ventral cirri are slender, tapered, with a distinct oblong terminal article; they arise far out on the parapodia and project beyond the setigerous lobe, but are not a third as long as the dorsals, anteriorly, posteriorly they are relatively longer. The parapodia are very large in the middle region of the body, with a swollen base and long setigerous lobe. Caudal cirri three; lateral ones very long, transversely annulated, tapered, acute, often coiled spirally; median one small and slender. Setæ numerous, the compound ones with a long, narrow terminal blade, bidentate at the tip; simple long setæ begin singly on the eighth or ninth setigerous segment; fascicles of capillary setæ appear on the eighteenth, in our largest example. Pharynx very dark colored, large, short, stout, straight, surrounded with a broad sheath, apparently unarmed, but sometimes showing a pale, oblong spot, that might be taken for a feeble tooth, near the anterior end; its sheath has a circle of soft papillæ in front; stomach brown, large, oblong, usually slightly constricted near the front end, equal in length to about four segments (or to six in alcohol); intestine very large, with two rounded brown lobes close to the stomach. Color generally dull orange-yellow, or orange-brown, medially, due to the internal organs; the external parts are whitish; buccal segment brownish, intestine yellowish brown. Length of the largest specimen, in alcohol, 12^{mm}. Taken at the surface, evening, July 22, 29, and August 15, 1881; August 3 to September 12, 1882. Described from life. Another very much smaller form, with about 32 segments, perhaps distinct from the above, occurred. In this the antennæ and tentacular cirri are shorter, more decidedly clavate; palpi shorter, scarcely visible from above; setæ with a shorter and less slender article. The stomach and pharynx are dark brown. Bunches of capillary setæ begin on the tenth body-segment. Length about 3^{mm}.

Grubea Websteri V.,* *Sphærosyllis*, sp., *Pædophylax longiceps* V., etc. The *Nereis megalops* V., both in the heteronereis-form (*Nectonereis*) and in the nereis-form (*N. alacris* V.), frequently occurred in our night excursions, and in September the young of this species of all sizes, from those with only six or eight segments, up to those that were 10^{mm} or more in length, occurred abundantly at the surface. These young are very active, translucent, and nearly white, with small, red specks over the surface. A very interesting new species, *Acrocirrus Leidyi* V.,† belonging to a genus hitherto not recorded from our coast, was taken at the surface several times this year, and also in 1881. *Podarke obscura* V. was often abundant at the surface, as well as in the soft mud, among eel-grass, in the harbor. Among other surface Annelida were *Cirrhinereis phosphorea* V. and *C. fragilis*, and a species of *Prionospio*, probably identical with *P. tenuis* (*Spiophanes tenuis* V., 1880). This was also taken from the harbor mud, in shallow water, last year. When perfect it has four pairs of gills, all fringed on one side, (Tr. Conn. Acad., iv, pl. xix, fig. 7). A singular larval form, probably belonging to this species, occurred once (September 9) at the surface.

Among the various larval forms of Annelids we were fortunate in obtaining a very large number of *Chætopterus pergamen-*

* *Grubea Websteri* V., sp. nov., Trans. Conn. Acad., iv, pl. 24, figs. 6–8. Small, slender, whitish, with about 33 segments. Three antennæ, both pairs of tentacular cirri, dorsal and caudal cirri all similar in shape, long-fusiform, thickest below the middle, tapering and acute, not differing much in size nor in length, but the first pair of dorsal cirri, and those following the eighth, are a little longer than the others or the antennæ; cirri longer than the breadth of the body opposite; ventral cirri small, slender. Head short, rounded in front and laterally; palpi large and prominent, tapered, united above nearly to the obtuse, rounded tips; eyes six; frontal ones minute, median largest and farthest apart, close to sides of head. Pharynx narrow, straight, a little swollen anteriorly, with a well-marked tooth close to the front edge; stomach oblong, occupying two to three segments, according to their extension; intestine with two rounded lobes, close behind stomach. Setæ with a rather long, flat, blade-like article, strongly fringed on the edge, with the tip distinctly bidentate, and not very slender; long, capillary, sexual setæ begin (when present) on the ninth setigerous segment, and continue on thirteen to seventeen. The eggs and young are carried on these same segments, usually four to each segment. Some examples (op. cit., pl. 25, fig. 2) similar in other respects, have no sexual setæ and only two eggs to a segment). Three to eight hind segments are without sexual setæ and eggs. Length, 3^{mm} to 4^{mm}. Surface, Newport, R. I., 1880; Wood's Holl, Mass., July 28 to September 12, 1881, 1882. Described from life.

† *Acrocirrus Leidyi* V., sp. nov., Trans. Conn. Acad., iv, pl. 19, fig. 2. Body slender, with distinct segments covered with small papillæ. Head changeable, usually rounded, obtuse; eyes four, the front pair very minute; hind pair larger and wider apart; two large, long, usually clavate antennæ on front of head, near together. A pair of large, long, clavate cirri on first four segments, like the antennæ, but larger, the length three or four times the breadth of body. Ventral compound setæ, with a very long, curved and hooked terminal article, begin, singly, on the second segment-bearing cirri; long, slender, capillary dorsal cirri begin singly on the fourth segment, but form fascicles of six to nine farther back. Color dark olive-green to dark brown; cirri and antennæ paler green with yellow tips. Length, 10 to 15^{mm}; diameter of largest, about 1^{mm}. Wood's Holl, surface, evening, August 2 to September 9, 1881 and 1882. Described from life.

taceus, in various stages, from very young ones up to those having the adult characters distinctly developed. Of these Mr. Emerton made an excellent series of drawings. The adults of this interesting species were dug from the sand just below low-water mark, at Naushon I.,* by our party. The largest of these had U-shaped tubes, 28 to 31 inches in length and over an inch in diameter in the middle. In each tube there was usually a crab (*Pinnixa chætopterana* St.), associated with the worm. These tubes show, very beautifully, the way in which their size is continually increased by the occupant, which is incapable of emerging from it. The worm makes longer or shorter slits in the parchment-like tube, wherever it is to be enlarged (probably using for this purpose the sharp, stiff, lance-like setæ of the anterior segments), and after spreading the tube, from within, to the desired extent, it closes up the opening by means of a fusiform patch (like a "gore" or "gusset"), of the same material as the original tube, but differing slightly in color or luster, so that when the tube is cut open these neat patches show very distinctly on its inner surface.

From the sands of Naushon, at Hadley Harbor, our party also procured several living examples of an European shell, *Tellimya* (or *Montacuta*) *ferruginosa*, not before found on our coast. It was associated, at low-water mark, with living specimens of *M. bidentata* and another species of the family Kelliadæ, *Corbula contracta*, etc. Drawings were made of the animals of all these by Mr. Emerton.

Of Gastropod veligers, about twenty species were taken in the surface nets. Some of these occurred in vast numbers, but I have not yet been able to identify more than half of the species. Among those recognized are *Anachis avara*, *Astyris lunata*, *Triforis nigrocincta*, etc. One of the largest and most interesting was that of a *Natica*. This had the velum divided into four long, narrow lobes, beautifully marked with brown at the tips. Many of these were kept till they lost the velum and developed the characterstic foot of *Natica*. The species is uncertain.

In a region that has been so thoroughly dredged in past years as Vineyard Sound, it was not to be expected that many new forms would be found, unless among the more minute species, or in those groups not hitherto studied on our coast. Yet one new Planarian,† of large size and with conspicuous colors, was taken, as well as various undescribed Rhabdocœla and Annelida.

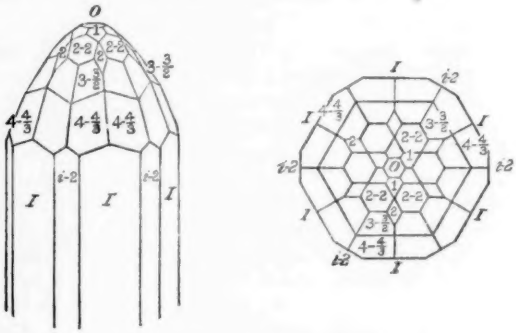
*This species was first discovered at this place in 1880 by Mr. Chas. Webster and Mr. Vinal N. Edwards, from whom I received specimens at that time.

† *Stylochopsis zebra* V., sp. nov. Body broad-elliptical, rather thick, or somewhat swollen. Tentacles small, near the front end, bearing several small ocelli; a cluster of small dorsal eyes in front of tentacles; minute, marginal ocelli, along the front edges. Color brown and pale yellow or whitish, in narrow, alternating, transverse stripes, which run directly across in the middle, but become more and more V-shaped as they approach each end. Length about 20^{mm}, breadth 12^{mm}. Great Harbor, shore; off Menemsha, 10 to 12 fathoms, September 6.

ART. XLI.—*Notes on some North Carolina Minerals;* by W. EARL HIDDEN.

[Continued from vol. xxii, p. 25.]

BERYL.—The accompanying figures represent the form of a remarkable crystal of beryl found some years since in Alexander county, North Carolina. It was found lying loose in the surface soil, on the land known as the Pendergrass land, which adjoins to the east that of the "Emerald and Hiddenite Mining Company." Soon after its discovery it went into the collection of Mr. J. A. Stephenson of Statesville, N. C., who yet retains it. It is of nearly faultless transparency, with only a slight aquamarine tint. All its planes are brilliantly polished. It is about 1^{cm} long and 30^{mm} in diameter.



The large development on this crystal of the rare planes $3\text{–}\frac{3}{2}$ and $4\text{–}\frac{4}{3}$ is unprecedented in mineralogical records. The work now going on in this new mineral region brings to light occasionally crystals of emerald and of beryl, exhibiting this same development of rare planes, but with the basal plane [*O*] very much larger in proportion.

COLUMBITE.—The mineral thought to be *æschynite* from Ray's mica mine, Yancey county, N. C., has, upon analysis, proved to be columbite. The crystals are unusually well formed and have been found in groups weighing over a pound. Their common parallel grouping is interesting.

URANINITE.—Careful determinations of the specific gravity of uraninite from Mitchell county, N. C., gave the following results for three different specimens: 8·968, 9·05, 9·218. Thus proving that it is not entirely free from alteration, though it has an appearance very much like magnetite.

"EUXENITE."—At my request Professor J. W. Mallett has lately examined the so-called "euxenite," from Wiseman's mica

mine, N. C., with results differing widely from those of Dr. J. L. Smith. The material for this analysis was obtained at the locality by the writer. The analyses by both Mallett and Smith are given below:

	Mallett.	Smith.
Nb_2O_5	47·09	54·12
$SnO_2 + WO_3$	·40	·21
Y_2O_3	13·46	24·10
Ce_2O_3	1·40	
$Di_2O_3 + La_2O_3$	4·00	
CaO	1·53	5·53
U_2O_3	15·15	9·53
FeO	7·09	·31
MnO		·08
H_2O	9·55	5·70
	99·67	99·58

Titanium was carefully sought for by Mallett but none was found; it is essential to true euxenite. I incline to the opinion of Professor Mallett, who, in a late letter to me, stated he had concluded that this so-called "euxenite" was only *altered samarskite.* Its intimate association with samarskite, its uncrystalline form, and the varying analyses, point to this conclusion.

FERGUSONITE.—Through the kindness of Professor Mallett I am enabled to give an analysis of the fergusonite from the new locality discovered by the writer in Burke county, N. C., where it was found to exist quite abundantly in the placers of the Brindletown gold district. The occurring form is a very acute octahedron, with the basal and hemihedral planes. Color, brown-black and crystals mostly covered with a gray crust, the faces hardly smooth. Sp. gr. 5·87 (Smith).

	Mallett.	Smith.
Nb_2O_5	43·78	48·12
Ta_2O_5	4·08	
$SnO_2 + WO_3$	·76	
Y_2O_3, etc.	37·21	40·20
Ce_2O_3	·66	
$Di_2O_3 + La_2O_3$	3·49	
U_2O_3	5·81	5·81
FeO	1·81	2·75
CaO	·65	
H_2O	1·62	1·50
	99·87	98·38

Prof. Mallett states further: "That it is useless to attempt any separation of the earths grouped under the head of yttria

(in an analysis made on a few grams of material) so long as competent chemists, working on many pounds of material, have not only not found any means of accurate separation, but are not even agreed as to the independent existence and number of the earths to be separated."

This Burke county fergusonite is thought to be identical with Shepard's "rutherfordite," described from the same locality many years ago on a very small amount of material.

ALLANITE.—I have lately identified this mineral at two new localities in North Carolina, i. e. at the emerald locality in Alexander county, in the feldspar veins of the gneiss; and in a decomposed feldspar at the Wiseman mica mine in Mitchell county. At the first-mentioned locality the mineral occurs as small, well-polished prisms, of a light brown color, sparsely distributed in the feldspar (oligoclase for the most part), and is not otherwise noteworthy excepting an unusually high percentage of La_2O_3, viz: 14 per cent. From the second named locality the crystals are of unusually perfect form for allanite, and contain over 8 per cent of yttria. Some of the crystals were 2^{cm} long and over 1^{cm} in thickness. They were all more or less covered with a thin reddish-gray crust due to alteration. Some few had become entirely altered into an allanite-gummite.

Below is an analysis by Mallett on the purest material then obtainable; its color was pitchy black, through thin edges slightly greenish:

	Mallett.	Norway.
SiO_2	39·03	33·60
Al_2O_3	14·33	12·58
Y_2O_3	8·20	20·83
Ce_2O_3	1·53	4·56
Fe_2O_3	7·10	13·48
FeO	5·22	
MnO	trace, $Na_2O+K_2O=$	·62
MgO	4·29	1·60
CaO	17·47	9·59
H_2O	2·78	3·34
	99·95	100·20

The relatively small proportion of cerium, writes Professor Mallett, and larger amount of yttrium, is remarkable, though paralleled by a Norway orthite. The oxygen ratio is essentially that of allanite and orthite.

Stony Point, N. C., Sept. 11, 1882.

ART. XLII.—*Martite of the Cerro de Mercado, or Iron Mountain, of Durango, Mexico, and certain iron ores of Sinaloa;* by B. SILLIMAN.

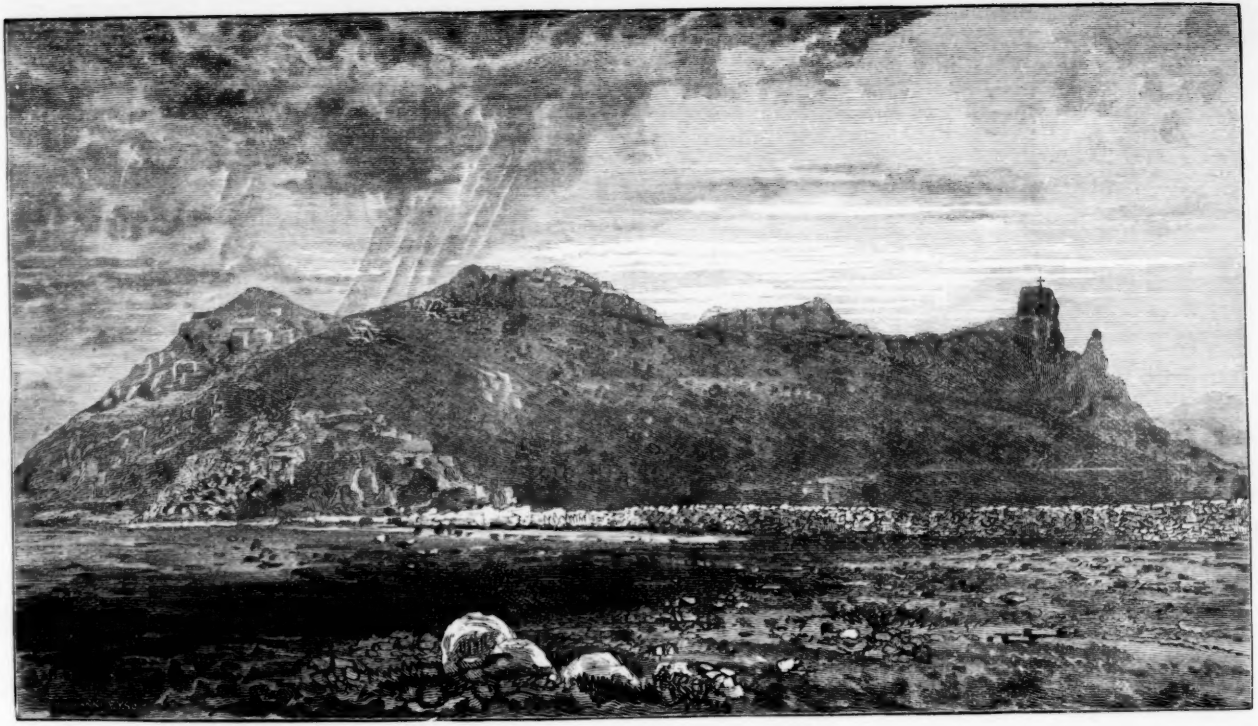
1. *Cerro de Mercado.*

A COLLECTION of specimens from the famous Iron Mountain of Durango has lately been placed in my hands by Mr. Edward P. North, Engineer of the Sinaloa and Durango Railroad Company, who obtained them, last year, in the discharge of his professional duties At first sight the octahedral crystals of very various size suggested only magnetite, but the magnet failed to attract the ore, while the streak immediately indicated hematite, and left no reasonable doubt that the whole mass was martite.

Fortunately, Mr. John Birkinbine, Engineer, of Philadelphia, had the goodness, about the time I received Mr. North's collections, to send me his "Report upon the Iron Mountain of Durango," of date March, 1882, from which I glean some facts which are of interest to mineralogists respecting this remarkable iron mass, which, so far as I am informed, is new to science.

The Cerro de Mercado rises abruptly from the plains on which stands the city of Durango, about one and a half miles to the north of the city. This hill is one mile long, a third of a mile wide, and from four hundred to six hundred feet high. Mr. Birkinbine does not confirm the statement of some observers that this deposit is a solid mass of iron ore. The surface of the hill, indeed, everywhere exposes masses of ore, which appear to be derived from one or more immense beds, or veins, of specular iron standing nearly vertical, the fragments of which form a talus on the slopes of the mountain and conceal completely the enclosing walls of rock. From samples of the country rock which I find in Mr. North's collection, these walls are of purple porphyry. Mr. Birkinbine finds "indications that the deposit is not all above ground, but extends far beneath the plain from which it projects." The striking view of the bold escarpment and cliffs of this mountain which accompanies Mr. Birkinbine's paper is by his courtesy reproduced herewith.

In the collection from Mr. North I find the crystals of martite of all sizes, from those measuring more than one inch on the side to druses of two to three millimeters. They are all simple crystals, the larger ones dull, sometimes iridescent, the smaller lustrous and quite black. There are no isolated crystals like those found in the original locality described by Spix and Martius, and mentioned, with other Brazilian locali-



Iron Mountain of Durango.

ties, by Mr. Derby in his paper published in May of this year.* All are firmly attached to the massive ore, some masses of which in my hands weigh ten to twenty pounds. There is nothing in the mode of occurrence of this ore, or in the chemical constitution, which lends any support to the opinion of Gorçeix that martite is derived from the transformation of pyrite. In support of this statement I am permitted to cite the analysis of an average sample made up from twenty-seven pieces of the Durango ore collected by Mr. Birkinbine, and submitted by him to Mr. Andrew S. McCreath, chemist to the second Geological Survey of Pennsylvania, being a commercial sample of the whole ore mass and not presenting fairly the constitution of the pure mineral. This "sample" gave the following results, viz:

Magnetic oxide of iron	2·071
Ferric oxide	77·571
Manganic oxide	·113
Titanic acid	·710
Lime	5·050
Magnesia	·364
Sulphuric acid	·212
Phosphoric acid	3·041
Silica	7·760
Loss on ignition (water, etc.)	1·984
Undetermined (Al_2O_3, etc.)	1·124
	100·00

corresponding to metallic iron 55·8 per cent. A purer specimen of the mineral gave separately 62·775 per cent metallic iron.

The powder of this ore is attracted by the magnet, but fragments of the size of grains of wheat are not affected by a magnet of moderate power.

This enormous mass of valuable iron ore, thanks to the near approach of the railway system of Mexico, is now likely to become of commercial importance.

2. *Sinaloa iron ores.*

In this connection it is interesting to note the chemical composition of certain other ores of iron from the State of Sinaloa in Mexico, also placed at my disposition by Mr. North. The analyses were made in the Iron Masters' Laboratory, Philadelphia, by Mr. Blodget Britton. In these the transformation of magnetite into martite, has proceeded only so far as to leave still about one-third of the original magnetite unchanged. Naturally these samples are more sensibly affected by the magnet. They are from Tepuche, Bescuino and Cosolu.

* This Journal, III, xxiii, p. 373.

Names of Iron Mines.

Composition.	Tepuche.	Bescuino.	Cosolu.
Metallic iron	65·08	66·75	67·25
Oxygen with the iron	26·98	27·85	28·01
Water	1·26	1·87	1·06
Silica	5·08	2·68	2·46
Phosphoric acid	·146	·075	·225
Sulphur	none	none	none
Titanic acid	none	none	none
Manganese	·08	trace	trace
Undetermined	1·374	·775	·995
	100·000	100·000	100.000
Ferric oxide	65·88	72·82	71·82
Magnetic oxide	26 18	21·68	23·44
Phosphorus with 100 metallic iron	·099	·047	·123

A few notes on the localities of these three iron deposits are of interest in this connection.

Tepuche is near the town of this name on the Rio de Humaya, ten or twelve miles west of the city of Culiacan. The iron occurs in porphyry resembling that of the Cerro de Mercado. It is a massive ore showing no crystalline forms, and occurs in blocks of a cubic yard and less, scattered along the apparent outcrop of a bed which shows again on another hill one-quarter of a mile off. It is cut by a strong stream of water 436 feet below the top of the ridge, the sides of the gulley being strewn with blocks and debris of this ore. Good lime exists abundantly within one and a half miles of this locality which is also on the line of the Sinaloa and Durango Railroad, in a country abounding in various hard woods and covered with dense underbrush, up to an elevation of about 1000 feet above sea level. Above this level and up to 5,000 or 6,000 feet, pines and other Coniferæ come in place of the hard woods.

Bescuino.—Little is known of this locality, which was not personally explored by Mr. North. It is reported to be a hill of 400 to 500 feet in elevation, less abundantly timbered than Tepuche. It is nearly due east from Culiacan, about twenty miles.

Cosolu.—The ore at this locality was all in loose masses; none was found in place. The summit of the hill on which it was found is 270 feet above the bottom of a dry arroyo. The surrounding rocks are calcareous. As Cosolu is an old mining region abounding in low grade veins of gold and silver; timber and wood for fuel is not found within 30 or 40 miles.

The question of the renovation of forests on the Gulf slopes of Sinaloa is one of much interest. In reply to my inquiry, Mr. North says: "I do not believe the hard woods can be of

rapid growth, but I think it safe to say that they will grow again, and in fact old clearings are seen covered with trees of second growth."

F. G. Weidner, Surveyor General of Sinaloa, is authority for the statement that the annual rain-fall at Culiacan in 1870 was 23 inches; in 1880, at Mazatlan, the chief seaport of Sinaloa, it was 35 inches, and in 1881 an exceptionally wet year, it reached the quantity (estimated) of 60 inches. It is remarkable that across the Gulf of California, namely, in the peninsula of Lower California, the rain-fall seldom reaches four inches.*

ART. XLIII.—*Contributions from the Physical Laboratory of Harvard College. The Thomson Effect;* by JOHN TROWBRIDGE and CHARLES BINGHAM PENROSE.

SIR WILLIAM THOMSON † first discovered that when an electrical current passes through a piece of metal, the ends of which are of different temperatures, it carries heat with it; the direction depending upon the character of the metal and the direction of the current. This phenomenon is known as the Thomson Effect. Le Roux ‡ subsequently verified Thomson's results, and gave an incomplete table of the effect in different metals. No especial pains have been taken hitherto in experimenting with pure metals. We have therefore thought it would be valuable to test the effect in as pure a metal as we could obtain by electrolysis. We have also extended Le Roux's table by the addition of the effect in nickel, which Thomson was unable to obtain, and also in carbon. An endeavor has been made to ascertain if the effect is reversible, and also to discover if it is modified in a magnetic field.

The strip of nickel, 45 centimeters long, 2·6 wide, and 2 millimeters in thickness, was placed with its flat surface horizontal. One face of a thermopile was placed at a fixed point on the surface of the nickel, separated from it by a thin piece of mica. A weight pressed upon the other surface. The thermopile was connected with a Thomson's reflecting galvanometer of six ohms resistance. The two extremities of the strip of nickel were connected with a battery of six Grove cells, the wires first passing through a key so that the direction of the current could be reversed. One end of the nickel was kept at

* The Topography, Ethnography and the Natural and Mineral Resources of Sinaloa; by Frederick G. Weidner, M. and C. E., Surveyor General of Sinaloa. Read before the Geog. Soc. of the Pacific, Nov., 1881. San Francisco, 1882.

† Phil. Trans., 1856, vol. iii, p. 661.

‡ Ann. de Chim. et Phys., 1867 [4], vol. x, p. 258.

the temperature of the air, 15° C.; the other at a constant red heat by means of a Bunsen burner. The metal was heated in this way from 9 A. M. to 3 P. M., until it reached a condition of thermal equilibrium, as shown by the galvanometer. The scale of the galvanometer was then moved until the spot of light came to 0. The current from the Grove cells was then passed for one minute, alternately in opposite directions, and the deflections of the galvanometer were read every quarter of a minute. Before the direction of the current was changed the circuit was each time broken, and the spot of light was allowed to fall to 0. The following table gives the results. The column marked "C–H" gives the deflections when the current was passing from cold to hot. The small numbers show which deflections in each pair were taken first.

C—H. Deflections taken every ¼ minute.					H—C. Deflections taken every ¼ minute.				
1	2	1	2	1	2	1	2	1	2
4·1	4·2	4·0	4·3	4·4	3·3	4·0	3·6	3·8	4·1
6·3	6·4	6·5	6·4	6·4	5·0	6·2	5·4	5·9	6·0
7·3	7·2	7·5	7·0	7·2	5·8	6·7	6·2	6·5	7·0
7·4	7·6	7·6	7·3	7·7	6·1	7·3	6·5	6·8	7·2

From this table it is obvious that more heat is evolved by a constant current per unit time in passing from the cold to the hot end of the nickel, than in passing in the opposite direction. The Thomson Effect in pure nickel is consequently negative; i. e., heat is absorbed by a current in passing from hot to cold, and evolved in passing from cold to hot. The above results were confirmed by many similar experiments, as will be seen later.

It was next determined to find whether the Thomson Effect was reversible; that is, whether the heat absorbed by a current in passing across a section of temperature t was equal to the heat evolved by the same current when passing in the opposite direction across the same section. This subject has important bearings on the thermodynamical theory of thermo-electricity.

The following method was pursued: Both ends of the nickel were at the temperature of the air, 15° C. The current from six Grove cells was passed as before, and the deflections of the galvanometer were observed every half-minute. The apparatus was arranged exactly as before. Column I of the accompanying table gives the deflections. One end of the nickel was now placed in melting ice. After one hour it reached a condition of thermal equilibrium, and the current from the Grove cells was passed alternately in opposite directions. The deflections are given in II and III.

If the deflections in II and III are subtracted from the corresponding deflections in I, we get the amount of deflection due to the Thomson Effect. It will be observed that all the deflections in II are less than those in I, and those in III are greater, as they obviously should be. The only inaccuracy in

I. Deflections taken every ½ minute.	II. H—C. Deflections every ½ minute.	III. C—H. Deflections every ½ minute.	II—I.	III—I.
1·8	1·8	2·0	0·0	0·1
2·6	2·4	2·8	0·2	0·2
2·9	2·65	3·15	0·25	0·25
3·1	2·75	3·25	0·35	0·15

this determination is due to the fact that we neglected the alteration in electrical resistance of the nickel due to the slight change in temperature.

The numbers in these tables are obviously too small to draw any conclusions. They, however, confirm the preceding results as to the direction of the Thomson Effect, and tend rather to prove than to disprove the reversibility of the effect. The experiment was repeated several times, but with no better result.

Experiments were also made to test the influence of magnetism on the Thomson Effect. Nothing but negative results were, however, obtained.

The strip of nickel was placed horizontally, with its flat surface perpendicular to the axis of a large electro-magnet—the strip being between the two poles of the magnet. One surface of the nickel was pressed against one pole; on the other surface was placed one face of the thermopile, while the opposite face was in contact with the second pole of the magnet. Mica was used, as in the previous experiments, to protect the faces of the pile. The whole was wedged, and pressed tightly together, and clamped by means of wire, the object being to prevent any motion of the nickel when the magnet was made. One end of the nickel was heated by a Bunsen burner, the other was at the temperature of the air. Six hours were required for the apparatus to reach a condition of thermal equilibrium. The electro-magnet was connected with thirty-eight freshly set-up bichromate of potash cells, with plates of large size. A current from eight Grove cells was now passed along the nickel, with and without the circuit of the magnet being made. The deflections of the galvanometer were exactly the same in each case, showing that in a magnetic field—at least of the strength in the experiment—the Thomson Effect was unaltered.

It is unfortunate that the strength of the field could not be

accurately obtained, as the batteries had been running about thirty minutes by the time the experiment was completed. The field, however, was very much stronger—as shown by rough tests—than in another experiment where the minimum value was found to be 184 times the vertical intensity of the earth's magnetism.

The determination of the relative value of the Thomson Effect in nickel, by the following method, gives, of course, but approximate results. The value, however, is probably as accurate as those given by Le Roux for other metals.

A strip of copper, of about the same dimensions as the nickel used before, was arranged exactly as the nickel had been. The thermopile was insulated from the strip by the same piece of mica, and the same weights were placed on the upper surface. One end of the copper was heated in boiling water, and when the apparatus had reached a condition of equilibrum, the deflection of the galvanometer was 35 centimeters. A current from four amalgamated Grove cells was now passed alternately in opposite directions along the bar, the deflections of the spot being taken, in each case, after one minute. The results are given in the left hand table.

C—H deflections taken every minute.		H—C deflections taken every minute.		Differences between the corresponding deflections.
12·0	2	13·0	1	1·0
12·3	1	13·1	2	0·8
12·1	1	13·4	2	1·3
12·0	2	12·8	1	0·8
Mean difference = 0·97				

C—H deflections taken every minute.		H—C deflections taken every minute.		Differences between the corresponding deflections.
14·5	1	13·3	2	1·2
14·3	2	13·3	1	1·0
14·3	1	13·4	2	·9
14·8	2	13 3	1	1·5
Mean difference = 1·15				

The strip of nickel was now substituted for the copper, everything else remaining exactly the same. One end of the nickel was heated, and the thermopile was placed on such a spot that the galvanometer gave a deflection of 35 centimeters. The same current was passed as above. The results are given in the right hand table. Let d= the mean difference in first table, and d'= that in the second, d and d' are then proportional to the elevation of temperature of the part of the bars under the pile, on account of the Thomson Effect. Let σ= coefficient of Thomson Effect, that is, σ is such a quantity that $\sigma d\theta$ represents the heat absorbed per unit current per unit time in passing from section at temperature θ to section at temperature $\theta+d\theta$. The heat evolved in unit section when the temperature is increased by $\frac{1}{2}d$. K is $\frac{1}{2}$Kd SD. Where K is a constant depending on the galvanometer, S is the specific heat, and D the density of the metal. If we consider the Thomson Effect to be constant under the pile, and θ and θ' to represent

the temperatures of the ends of the space covered by the pile we have:

$$\sigma(\theta-\theta_1)=K\frac{d}{2}SD$$

and the similar expression for nickel:

$$\sigma_1(\theta-\theta_1)=K\frac{d_1}{2}S_1D_1$$

$$\therefore \quad \frac{\sigma_1}{\sigma}=\frac{d'}{d}\cdot\frac{S'}{S}\cdot\frac{D_1}{D} \qquad \text{I}$$

Equation I then gives the relative value of the coefficient of the Thomson Effect at any temperature θ.

$S=\cdot095$ $S_1=\cdot108$ $D=8\cdot9$ $D_1=8\cdot3$ $d=0\cdot97$ $d'=1\cdot15$

$$\therefore \quad \frac{\sigma'}{\sigma}=1\cdot25 \quad \therefore \sigma'=1\cdot25\sigma.$$

In Le Roux's table $\sigma=2$. $\therefore \sigma'=2\cdot50$, σ and σ' are, however, of opposite sign. Introducing nickel Le Roux's table becomes:

+		−	
Sb	64	Fe	31
Cd	31	Bi	31
Zn	11	Arg	25
Ag	6	Pt	18
Cu	2	Ni	2·25
		Al	0·1
		Sn	0·1

The Thomson effect in carbon was next investigated. The carbon used was the graphite of the common carpenter's lead-pencil. The pencils which gave the best results were Faber's.

Attempts were first made to measure the direction of the Thomson Effect in the same way as in the case of nickel, that is, by placing a face of the thermopile on one surface of the carbon; the two ends of the carbon being maintained at constant temperatures, and passing the electric current alternately in opposite directions. This method was unsuccessful from the fact that one Grove cell heated the carbon to such a degree that in one minute the spot of light was thrown off the galvanometer scale; thus rendering it impossible to measure, with any accuracy, the rate at which the deflection increased.

The method of Le Roux was then tried of using two strips of carbon, each face of the pile being in contact with one strip. This method not only doubles the deflection due to the Thomson Effect, but also greatly diminishes the deflection due to the heat evolved on account of the electrical resistance of the carbon. If the two strips of carbon were exactly the same in all their physical properties, and the contacts with the faces of the thermopile were the same on each side, the latter deflections would evidently be entirely eliminated.

Two carpenters' pencils were split longitudinally, the lead being left in one-half of the wood. They were then tightly bound, parallel, against each face of the thermopile, and insulated from it by thin pieces of mica. Especial care was taken to fasten the carbons firmly so as to prevent any motion from the passage of the current. The pencils were placed perpendicularly, the lower ends in two vessels of mercury, surrounded by melting ice; the upper ends were at the temperature of the air. The upper ends were electrically connected and the wires from a battery of three Grove cells were placed in the vessels of mercury. The thermopile was connected with a reflecting galvanometer of six ohms resistance.

When the system had reached a condition of thermal equilibrium, the current from the battery was passed, and the observations were made. The vessels of mercury and the corresponding pencils are denoted by "*a*" and "*b*." The current entered alternately in "*a*" and *b*," the deflections of the galvanometer being taken, in each case, every half minute. The deflections showed that the pencil "*a*" was warmer than "*b*," but the difference of temperatures was greater in one case than in the other.

The following table represents the results of two sets of experiments. The small numbers at top show which column of each pair was taken first.

First Experiment.			*Second Experiment.*		
Current enters at "*a*."	Current enters at "*b*."	Difference proportional to 47 E.	Current enters at "*a*."	Current enters at "*b*."	Difference proportional to 47 E.
2	1		1	2	
21·0	20·8	0·2	20·8	20·2	0·6
34·5	32·4	2·1	34·7	32·8	1·9
2	1		1	2	
21·2	21·0	0·2	19·5	18·2	1·3
34·5	33·0	1·5	31·0	29·3	1·7
			37·0	34·2	2·8
2	1		1	2	
21·4	20·6	0·8			
34·3	32·8	1·5	19·8	18·0	1·8
			31.8	29·2	2·6
2	1		37·3	34·0	3·3
21·7	21·6	0·1	1	2	
36·0	34·3	1·7			
42·4	40·0	2·4	20·0	18·8	1·2
			32·6	30·4	2·2
2	1		38·7	35·7	3·0
23·0	21·7	1·3	1	2	
38·2	35·0	3·2			
45·5	41·2	4·3	21·0	19·8	1·2
			33·8	31·3	2·5
2	1		39·8	36·3	3·5
23·5	23·0	0·5	1	2	
39·0	37·0	2·0			
45·8	43·8	2·0	20·0	19·0	1·0
			32·2	29·8	2·4
			37·4	34·3	3·1

From this table it appears that the Thomson Effect in ordinary graphite is negative; that is, heat is apparently evolved when the current passes from cold to hot, or the negative current carries heat with it. The differences in the last columns are obviously proportional to four times the Thomson Effect—assuming that the effect is reversible. It also appears from the table that the effect increases as the temperature increases, which is in accordance with Tait's assumption.

These experiments were repeated with the graphite from other kinds of pencils, but in no case was the effect nearly as marked as in Faber's. Even in the case of Faber's pencils many trials were made before satisfactory results were obtained.

Equations representing the thermal condition of a bar when acting as a conductor of heat and electricity may be deduced as follows: One end of the bar is supposed to be maintained at a constant temperature, the other at that of the air, and the electric current is supposed to be constant. For simplicity we will assume that the specific electrical resistance of the bar is constant throughout, i. e. is independent of slight differences of temperature.

The quantity of heat, H, evolved by the current in time δt, in the section of the bar $S\delta x$—S being the area of a section—is represented by

$$H = I^2RS\delta x . \delta t \qquad I$$

x = distance of the section from heated end. If we assume that the thermal conductivity is unaltered by the slight rise in temperature due to the current, it can easily be seen that the flow of heat due to conduction is unaltered by the current. Hence we can consider that the heat evolved by the current is partly used in raising the temperature of the section $S\delta x$, and that all the rest escapes from the surface by radiation.

The Thomson Effect is, at present, purposely neglected.

The bar is supposed to have reached a permanent condition as regards conduction before the current was passed. Let θ be the temperature of the section of the bar we are considering before the current passes. Let h = the exterior conductivity or velocity of cooling.

Let p = the rise of temperature above θ when the current passes.

Assuming Newton's law of cooling, the heat radiated on account of the rise of temperature p is proportional to ph, and the quantity radiated from the section in time δt, from the same cause, is

$$H_1 = phl\delta x . \delta t \qquad II$$

l = the periphery of the bar.

In time δt the increase of temperature p becomes $p+\delta p$, and the heat developed in the section by this increment is

$$H_2 = CSD\delta x \,.\, \delta p \qquad III$$

As we saw that the heat of the current was expended only in the ways represented by II and III, we have

$$H = H_1 + H_2 \qquad IV$$

If we now consider the influence of the Thomson Effect, we simply add that a certain quantity of heat is absorbed or evolved by the current in the section $S\delta x$—distinct from that represented by I_2R.

If σ = the coefficient of the Thomson Effect, the heat absorbed or evolved due to this effect is, in time δt,

$$H_3 = I\sigma\delta\theta \,.\, \delta t \qquad V$$

The effect being proportional to the current, and σ being defined as such a quantity that $\sigma\delta\theta$ represents the heat absorbed, or evolved, in passing from a point at temperature θ to $\theta+\delta\theta$, per unit current per unit time. Introducing this effect in IV,

$$H = H_1 + H_2 + H_3 \qquad VI$$

As the total value of the excess of heat—due to the current—in the section can be considered as made up of these quantities. Substituting the values in VI from I, II, III, V, and transposing

$$phl\delta x \,.\, \delta t = I^2RS\delta x \,.\, \delta t - CSD\delta x \,.\, \delta p - I\sigma\delta\theta \,.\, \delta t$$

$$\therefore \qquad phl = I^2RS - CSD\frac{\delta p}{\delta t} - I\sigma\frac{\delta\theta}{\delta x}$$

or at the limit:—

$$\frac{dp}{dt} = \frac{1}{CSD}\left[I^2RS - phl - I\sigma\frac{d\theta}{dx}\right] \qquad VII$$

This equation gives the rate at which the temperature rises when the current passes, and will approximately apply to the preceding experiments.

When the temperature of the bar becomes permanent,

$$\frac{dp}{dt} = 0$$

and VII becomes

$$I^2RS - phl - I\sigma\frac{d\theta}{dx} = 0$$

$$\therefore \qquad p = \left[I^2RS - I\sigma\frac{d\theta}{dx}\right]\frac{1}{hl} \qquad VIII$$

giving the excess of temperature due to the current in the permanent condition of the bar.

The values in VIII are all easily determined except σ and h. The differential coefficient $\frac{d\theta}{dx}$—the rate of change of temperature

due to conduction along the bar—can readily be found by experiment; or deduced by analysis, as in the case of an infinite square bar where

$$\theta = a\mathfrak{E}^{-kx} \quad \text{and} \quad \frac{d\theta}{dx} = -ak\mathfrak{E}^{-kx}.$$

As p may easily be determined by experiment, the equation can be used to determine σ as

$$\sigma = \frac{\mathrm{I^2RS} - phl}{\mathrm{I}\frac{d\theta}{dx}} \qquad \text{IX}$$

If Tait's assumption that $\sigma = \mathrm{MT}$, where M is some constant and T the absolute temperature, is true, we might obtain two values of σ, for two points of the bar, the temperature of which was known, eliminate h from the two equations, and thus obtain a value for M. If we performed the same operation for two other points, we should get another value for M, and could verify Tait's assumption if this value was equal to the preceding.

The sources of error in the preceding investigation are due to assuming Newton's law of cooling, to neglecting the change of electrical resistance due to a change of temperature, and to partly neglecting the change of thermal conductivity due to the same cause.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Carbon dioxide of the Atmosphere.*—The statement is commonly made in text-books that the amount of carbon dioxide in the atmosphere varies from four to six volumes in ten thousand; being based on the investigations of De Saussure, Boussingault and others. Two important memoirs have been lately published upon this subject which show that the value above given is very considerably too high. The first of these is by Reiset. The apparatus which he employed consisted of two aspirators, which, to secure accuracy, were of large size, containing about 600 liters each. They were made of strong galvanized iron and were provided with stopcocks of brass. Each was mounted, with the axis vertical, upon a cart carrying also a small shed in which was the absorption apparatus. The aqueous vapor was absorbed by a weighed tube containing fragments of pumice moistened with concentrated sulphuric acid. The carbon dioxide was absorbed in bulb tubes containing a solution of barium hydrate already saturated with carbonate. The barium solution was titred with a graduated sulphuric acid both before and after the known volume of air had been passed through it. The difference gave the barium which had been converted into carbonate.

On the scale of the experiments an error of an entire cubic centimeter in the amount of CO_2 is of comparative unimportance, since it represents only $\frac{1}{500000}$ of the whole. The experiments were made at a field station about 8 kilometers from Dieppe at an altitude of 96 meters above the sea. Here one of the aspirators was permanently installed while the other was transported from place to place. Three series of experiments were made with the former apparatus. The first extended from September 9, 1872, to August 20, 1873, 92 experiments. The second from June 17 to November 14, 1879, 91 experiments. The third from June 19 to August 28, 1880, 37 experiments. The results are given in tabular form, the final mean being given as follows:

Number of series.	Number of experiments.	Volume of dry air at 0° and 760 in liters.	Carbon dioxide at 0° and 760 in cubic cent.	Carbon dioxide in 100,000 volumes of air.
Series 1	92	532·906	156·8	29·42
Series 2	91	527·539	157·1	29 77
Series 3	37	513·717	152·5	29·68
Mean of	220 expts.	524·720	155·5	29·62

The aspirator contained as a mean 678·294 grams of dry air at 0° and 760 mm. This contained 0·307 gram CO_2; giving by weight 4·52 parts of CO_2 in 10,000 of air as the mean of the 220 experiments. The absolute maximum observed was 35·18 volumes in 100,000, observed July 23, 1880; the absolute minimum 27·43, observed on September 2, 1879. The air at night contained more CO_2 than during the day. Cloudy weather and fog increase the CO_2, clear weather diminishes it. It is less in summer than in winter. With the second aspirating apparatus, a series of 27 experiments were made in a grove of young trees and gave 29·17 volumes CO_2 in 100,000 of air. Air taken near a vigorous growth of clover red with flowers, in the month of June, contained 28·98 volumes CO_2. Air taken 3 dm. above the ground in a field of barley mixed with lucerne, in July, gave 28·29 volumes CO_2. Since during the same periods, the CO_2 in the air at the field station was 29·02, 29·15 and 29·33 volumes, the reduction by the vegetation is evident. Experiments made in Paris, in the Rue de Vigny near the Parc de Monceaux in 1873, 1875 and 1879, showed a mean of 31·68 volumes CO_2 in 100,000; the maximum being 35·16 on the 27th January, 1879, and the minimum 29·13 on May 31, 1875.

The second memoir is by Müntz and Aubin. They determined the carbon dioxide by absorbing it by pumice stone moistened with potassium hydrate; the gas being subsequently set free and its volume measured. By means of a gasometer of 300 liters capacity, a known volume of air was passed, at the rate of three liters per minute, through a tube 85 to 90 cm. long and 20 mm. in diameter, containing pumice in fragments the size of a bean moistened with 50 c.c. of a solution of potassium hydrate free from CO_2. These absorption tubes were prepared previously in sufficient number, being drawn to a point at each end and sealed till wanted. After the absorption they were again sealed and the

CO_2 was determined at leisure. Two stations for the lower levels were used, one at the Conservatoire des Arts et Metiers in Paris, 6 meters above the ground, the other near the farm of the Institut Agronomique at Gravelle, 4 meters high. As the result of 35 experiments in the open plain of Vincennes, the amount of CO_2 as a mean was found to be 2·84 volumes in 10,000 of air. Within the court of the Institut Agronomique, as a mean of 12 experiments 2·98 volumes. And in Paris, as a mean of 30 experiments, 3·19 volumes. For the higher levels, the Pic du Midi was selected, situated in the Pyrenees and 2,877 meters above the sea. As a mean of 14 observations, made from the 9th to the 14th of August, 1881, the amount of CO_2 was found to be 2·86 volumes in 10,000; thus showing the uniformity of the diffusion of carbon dioxide gas in the atmosphere.

In a note upon these researches, DUMAS gives an excellent summary of them as well as those of Schulze and Schlœsing, the latter upon the preservation of the balance by the dissociation of the hydro-calcium carbonate in the water of the sea whenever the CO_2 in the air falls below its normal value. Schulze found the CO_2 for 1869 to be 2·8668 volumes, for 1870 to be 2·9052 volumes and for the first half of 1871 to be 3·0126 volumes in 10,000 of air.—*Ann. Chim. Phys.*, V, xxvi, 145, 222, 254, June, 1882.

G. F. B.

2. *On a Basic Copper Sulphate.*—STEINMANN has produced a basic copper sulphate by heating a cold saturated solution of blue vitriol for about thirty minutes to the temperature of 240° to 250° in a close vessel. Crystalline crusts of a green color are deposited, insoluble in water but soluble in acids. On analysis, the salt gave 68·0–69·2 CuO, 23·1 SO_3 and 7·8–7·9 water; corresponding to the formula $(CuO)_6(SO_3)_2(H_2O)_3$ which requires 69·0 of CuO, 23·2 of SO_3 and 7·8 of water.—*Ber. Berl. Chem. Ges.*, xv, 1411, June, 1882.

G. F. B.

3. *On the Relation between Magnetic Rotatory Polarization and Chemical Composition.*—PERKIN has studied the influence of chemical composition upon the power of rotating the plane of polarization when under magnetic influence. The apparatus employed was that of Becquerel, the substances to be examined being placed in tubes about 10 cm. long, closed by glass plates, the ends being inserted a short distance into openings in the armature of an electro-magnet. Water and carbon disulphide were used as standards of comparison. At first the magnetic rotatory effect of unit-lengths of the liquids was determined; but the results seemed to bear little or no relationship to the chemical composition of the bodies examined. Moreover, no useful result could be expected from the calculated differences obtained from liquid substances; since, as the homologous series is ascended, the effect of increasing the molecule by CH_2 upon a unit-length becomes smaller and smaller, as also does any property which, like that of rotation, is based upon it. Since, however, unit-lengths of vapors contain equal numbers of molecules, the exam-

ination of vapors would give results free from this objection. The apparatus required to determine the magnetic rotatory power of gases is bulky and complicated. By multiplying the observed rotation of the liquid, however, by its molecular weight, and dividing the product by the density, an accurate molecular value is obtained. This, divided by a similar value given by the standard, yields a constant which the author calls the "molecular coefficient of magnetic rotation." Taking water as unity, the numbers calculated in this way show very clearly the dependence of magnetic rotation on chemical composition. With the iodides of the alcohol radicals, for example, the molecular rotatory power is as follows: methyl 9·07, ethyl 10·19, propyl 11·39, amyl 13·4; the differences for an increase of CH_2 being 1·12, 1·20 and 2·00 (=1·0×2) respectively. Taking De la Rive's and Becquerel's work in conjunction with his own, the author finds 1·06 for the difference of CH_2 between methyl and ethyl, and between ethyl and propyl alcohols, 1·14 between propyl and butyl alcohols, and 1·12 between butyl and amyl alcohols. The molecular rotatory power of amylene was found to be 5·87; and since C_5H_{10} is $CH_2 \times 5$, the value for amylene calculated would be 5·5. De la Rive had shown that isomeric and metameric bodies give different magnetic rotations; the molecular rotatory power of amyl alcohol being 5·95, and that of amylene hydrate being 5·81. Perkin finds that ethylidene chloride gives a lower number than ethylene chloride. Further results are promised.—*J. Chem. Soc.*, xli, 330, July, 1882. G. F. B.

4. *On the Vapor density of Chlorine peroxide.*—Pebal and Schacherl have determined experimentally the vapor density of chlorine peroxide, with a view to fix its molecular formula. The gas was prepared by gently heating a mixture of oxalic acid, potassium chlorate and dilute sulphuric acid (one of acid and two of water); Schacherl having shown that the gas thus obtained contains scarcely a trace of free chlorine. That the peroxide is a definite chemical compound Pebal had proved by showing that its composition did not change by diffusion into an indifferent gas. The gas as evolved was collected in a tube placed in a freezing mixture, where it condensed to a liquid. When about 5 or 6 c.c. had accumulated, the entrance tube was closed by a ground stopper, and the delivery tube connected by a ground joint to the weighing cylinder. This was a tube of 130 c.c. capacity closed at both ends with glass cocks, and immersed in water contained in a tinned iron cylinder and kept at a temperature one degree above the boiling point of the peroxide. On removing the freezing mixture from the tube, the liquid in it boiled and the heavy vapor streamed through the weighing tube and escaped into a chimney. Water at 30° surrounded this tube constantly and its temperature was kept uniform by agitation. When the liquid had nearly all evaporated, the lower cock of the weighing tube was first closed, and then the upper, the temperature of the water and the barometric pressure being noted. The

tube was then removed and weighed. The constants of the tube having been previously determined, the new weight after making the necessary reductions, gave the density at 10·7° C. and 718·05 mm. as 2·3894 referred to air as unity or as 34·50 referred to hydrogen. The density calculated from the formula ClO_2 is 33·64 and from Cl_2O_4 is 67·29. Hence the authors conclude that there is no ground for the assumption that molecules of the composition Cl_2O_4 have any actual existence.—*Liebig's Ann.*, ccxiii, 113, June, 1882. G. F. B.

5. *On Perchloric acid.*—BERTHELOT has made a study of perchloric acid with special reference to its thermo-chemical relations. He confirms Roscoe's three hydrates, $HClO_4$, $HClO_4H_2O$ and $HClO_4(H_2O)_2$. The first of these he has obtained crystallized by placing the liquid acid containing a few per cent of water in excess in a freezing mixture. The crystals are freed from the mother liquor, melted and again crystallized. An acid is thus obtained melting about 15°, having the above composition and possessing so strong an attraction for water as to give off thick white fumes in the air. When the liquid acid, $HClO_4$, is dissolved in 100 times its weight of water at 19°, it evolves 20·3 calories; an enormous quantity surpassing that given by any other acid known. This result explains the remarkable difference which exists between this acid when diluted with water, in which condition it is nearly as stable as dilute sulphuric acid, and the undiluted acid $HClO_4$, which inflames HI gas and acts with explosive violence on oxidizable bodies. Indeed in dilute solution perchloric acid is not reduced by any known substance. Neither sulphurous oxide, hydrogen sulphide, hyposulphurous acid, hydrogen iodide, free hydrogen, zinc in presence of acids, sodium amalgam in presence of pure water, acids or alkalies, nor even electrolysis, exerts any action. The perchlorates when dissolved are as stable as the sulphates. The second hydrate, $HClO_4H_2O$, evolves 7·7 calories, and the third, $HClO_4(H_2O)_2$, evolves 5·3 calories on being dissolved; and therefore they appear to be but a little more active than the dilute acid. The heat of formation of liquid $HClO_4$ (from HCl gas and O_4) evolves 2·9 calories; while from $Cl+O_{3½}+HO_½$ gaseous, 9·9 calories, or 14·9, if the water be liquid, are evolved. Dilute $HClO_4$, from HCl dilute and O_4, causes no heat change; and from Cl gaseous $+O_{3½}+HO_½$ liquid, there is an absorption of 4·9 calories. These numbers account for the difference in the stability of the concentrated and the dilute acid, and also for the readiness with which the former is decomposed. Again, in the decomposition of the perchlorates, $KClO_4$ solid $=KCl$ solid $+O_4$ absorbs 7·5 calories; $NaClO_4$ solid $=NaCl$ solid $+O_4$ absorbs 3·0 calories; and $Ba_{½}ClO_4$ solid $=Ba_{½}Cl$ solid $+O_4$ absorbs 1·1 calories. Hence when a perchlorate changes into a chloride heat is absorbed, the change not being explosive; contrary to what is true of the chlorates. Hence the change of potassium chlorate into perchlorate by heat is exothermic. Ammonium perchlorate should be explosive, since NH_4ClO_4 solid $=Cl+O_2+$

$N + (H_2O)_2$ liquid, evolving 58·3 calories; or if the resulting water be in vapor 38·3 calories. In fact, when melted, this salt becomes incandescent, taking the spheroidal form, the brilliant globule decomposing rapidly into free chlorine, oxygen and water, with the production of a yellowish flame; resembling somewhat ammonium nitrate in its action.—*Bull. Soc. Ch.*, II, xxxviii, 1, July, 1882. G. F. B.

6. *Diffusion of Gases.*—K. WAITZ concludes from his observations that the diffusion coefficient for the free diffusion of two gases into each other, is not a constant. It decreases after the beginning of the diffusion, in a given section, and soon reaches for any given section a constant limit. The change of this limiting value from one section to another is proportional to the distances of the sections from the free surface of the diffusion vessels.—*Ann. der Physik und Chemie*, No. 10, 1882, pp. 201–236. J. T.

7. *Diamagnetism of Bismuth in absolute measure.*—Various observers differ in regard to the diamagnetism of bismuth. H. A. v. ETTINGSHAUSEN has made a new determination of it by four different methods, and has obtained the mean value of $k = 13{\cdot}9910^{-6}$. —*Ann. der Physik und Chemie*, No. 10, 1882, 272–305. J. T.

8. *Pressure of Saturated Mercury Vapor.*—The results of Regnault and of later observers differ. Hagen has lately made some determinations, which in turn are scrutinized by H. HERTZ. The latter finds results which are smaller than those of Regnault, but approximate to those of the latter with increasing temperature, and nearly coincide with them at 220°. They are, however, greater than Hagen's above 80°, coincide very nearly with his between 80° and 100°, and are smaller below 80°. The pressure of mercury vapor at the ordinary temperature of the air is less than one thousandth of a millimeter.—*Ann. der Physik und Chemie*, No. 10, 1882, pp. 193–200. J. T.

9. *The Microphone.*—In a paper on the recent progress in Telephony, read at the Southampton meeting of the British Association, Mr. W. H. PREECE referred to the theory that the action of the microphone is due to the effect of heat which is generated by a current of electricity passing between points of carbon which are at variable distance. This theory appeared to him to be the true one. Carbon is inoxidizable and infusible, is a poor conductor, and has its resistance lowered when heated. These properties make it especially suitable for microphones. The resistance of microphones is very variable. Theory demands that a carbon transmitter should have the lowest possible resistance, but this is not true in practice. Theory also asserts that the resistance of the secondary coil of the induction coil should be equal to that of the line it works, but practice proves the reverse. The conditions due to heat in the microphone and to self-induction in the induction coil are apparently too complicated to be brought yet into the region of mathematical analysis.—*Nature*, Sept. 21, 1882. J. T.

10. *Telegraphy without a Cable.*—Mr. W. H. PREECE recently tried the following experiment. "Large metal plates were im-

mersed in the sea at Portsmouth and Ryde, six miles apart, and at Hurst Castle and Sconce point, one mile apart. The Portsmouth and Hurst Castle plates were connected by a wire passing through Southampton, and the Ryde and Sconce Point plates by a wire passing through Newport; the circuit was completed by the sea, and signals were passed easily so as to be read by the Morse system, but speech was not practicable."—*Nature*, Sept. 21, 1882. J. T.

11. *Sunlight and Skylight at High Altitudes.* From the Proceedings of the Meeting of the British Association at Southampton, (*Nature*).—Professor Langley, following Captain Abney, observed: The very remarkable paper just read by Captain Abney has already brought information, upon some points which the one I am about, by the courtesy of the Association, to present, leaves in doubt. It will be understood then that the references here are to his published memoirs only, and not to what we have just heard.

The solar spectrum is so commonly supposed to have been mapped with completeness, that the statement that much more than one half its extent is not only unmapped but nearly unknown, may excite surprise. This statement is, however, I think, quite within the truth, as to that almost unexplored region discovered by the elder Herschel, which lying below the red and invisible to the eye, is so compressed by the prism, that though its aggregate heat effects have been studied through the thermopile, it is only by the recent researches of Capt. Abney that we have any certain knowledge of the lines of absorption there, even in part. Though the last named investigator has extended our knowledge of it to a point much beyond the lowest visible ray, there yet remains a still remoter region, more extensive than the whole visible spectrum, the study of which has been entered on at Allegheny, by means of the linear Bolometer.

The whole spectrum, visible and invisible, is powerfully affected by the selective absorption of our atmosphere, and that of the sun; and we must first observe that could we get outside our earth's atmospheric shell, we should see a second and very different spectrum, and could we afterward remove the solar atmosphere also, we should have yet a third, different from either. The charts exhibited, show:—

1st. The distribution of the solar energy as we receive it, at the earth's surface, throughout the entire invisible as well as visible portion, both on the prismatic and normal scales. This is what I have principally to speak of now, but this whole first research is but incidental to others upon the spectra before any absorption, which though incomplete, I wish to briefly allude to later. The other curves then indicate:—

2d. The distribution of energy before absorption by our own atmosphere.

3d. This distribution at the photosphere of the sun.

The extent of the field, newly studied, is shown by this drawing (chart exhibited). Between H in the extreme violet, and A in the farthest red, lies the visible spectrum, with which we are familiar, its length being about 4,000 of Ångström's units. If, then, 4,000 represent the length of the visible spectrum, the chart shows that the region below extends through 24,000 more, and so much as this as lies below wave-length, 12,000, I think, is now mapped for the first time.

We have to $\lambda = 12{,}000$, relatively complete photographs published by Capt. Abney, but, excepting some very slight indications by Lamansky, Desains, and Mouton, no further guide.

Deviations being proportionate to abscissæ, and measured solar energies to ordinates, we have here (1) the distribution of energy in the prismatic and (2) its distribution in the normal spectrum. The total energy is in each case proportionate to the area of the curve (the two very dissimilar curves inclosing the same area), and on each, if the total energy be roughly divided into four parts, one of these will correspond to the visible, and three to the invisible or ultra-red part. The total energy, at the ultra violet end, is so small then as to be here altogether negligable.

We observe that (owing to the distortion introduced by the prism) the maximum ordinate representing the heat in the prismatic spectrum is, as observed by Tyndall, below the red, while upon the normal scale this maximum ordinate is found in the orange.

I would next ask your attention to the fact that in either spectrum, below $\lambda = 12{,}000$ are most extraordinary depressions and interruptions of the energy, to which, as will be seen, the visible spectrum offers no parallel. As to the agent producing these great gaps, which so strikingly interrupt the continuity of the curve, and as you see, in one place, cut it completely in two. I have as yet obtained no conclusive evidence. Knowing the great absorption of water vapor in this lowest region, as we already do, from the observations of Tyndall, it would, *à priori*, seem not unreasonable to look to it as the cause. On the other hand, when I have continued observations from noon to sunset, making successive measures of each ordinate, as the sinking sun sent its rays through greater depths of absorbing atmosphere, I have not found these gaps increasing as much as they apparently should if due to a terrestrial cause, and so far as this evidence goes, they might be rather thought to be solar. But my own means of investigation are not so well adapted to decide this important point as those of photography, to which we may yet be indebted for our final conclusion.

I am led from a study of Capt. Abney's photographs of the region between $\lambda = 8{,}000$ and $\lambda = 12{,}000$ to think that these gaps are produced by the aggregation of finer lines, which can best be discriminated by the camera, an instrument, which, where it can be used at all, is far more sensitive than the bolometer; while the latter, I think, has on the other hand some advantage in affording

direct and trustworthy measures of the amount of energy inhering in each ray.

One reason why the extent of this great region has been so singularly underestimated is the deceptively small space into which it appears to be compressed by the distortion of the prism. To discriminate between these crowded rays I have been driven to the invention of a special instrument. The bolometer, which I have here, is an instrument depending upon principles which I need not explain at length, since all present may be presumed to be familiar with the success which has before attended their application in another field, in the hands of the President of this Association.

I may remark, however, that this special construction has involved very considerable difficulties and long labor. For the instrument here shown, platinum has been rolled by Messrs. Tiffany, of New York, into sheets, which as determined by the kindness of Professor Rood, reach the surprising tenuity of less than $\frac{1}{250000}$ of an English inch (I have also iron rolled to $\frac{1}{150000}$ inch), and from this platinum a strip is cut $\frac{1}{125}$ of an inch wide. This minute strip, forming one arm of a Wheatstone's bridge, and thus perfectly shielded from air currents, is accurately centered, by means of a compound microscope, in this truly turned cylinder, and the cylinder itself is exactly directed by the arms of this Y.

The attached galvanometer responds readily to changes of temperature of much less than $\frac{1}{10000}$° Fahr. Since it is one and the same solar energy, whose manifestations we call "light" or "heat," according to the medium which interprets them, what is "light" to the eye is "heat" to the bolometer, and what is seen as a dark line by the eye is felt as a cold line by the sentient instrument. Accordingly if lines analogous to the dark "Frauenhofer lines" exist in this invisible region they will appear (if I may so speak) to the bolometer as cold bands, and this hair-like strip of platina is moved along in the invisible part of the spectrum till the galvanometer indicates that all but infinitesimal change of temperature caused by its contact with such a "cold band." The whole work, it will be seen, is necessarily very slow; it is in fact a long groping in the dark, and it demands extreme patience. A portion of its results are now before you.

The most tedious part of the whole process, has been the determination of the wave-lengths. It will be remembered that we have (except through the work of Capt. Abney, already cited, and perhaps of M. Mouton) no direct knowledge of the wave-lengths in the infra-red prismatic spectrum, but have hitherto inferred them from formulas like the well-known one of Cauchy's, all of which that are known to me appear to be here found erroneous by the test of direct experiment; at least in the case of the prism actually employed.

I have been greatly aided in this part of the work by the remarkable concave gratings lately constructed by Professor

Rowland of Baltimore, one of which I have the pleasure of showing you.

The spectra formed by this fall upon a screen in which is a fine slit, only permitting nearly homogeneous rays to pass, and these, which may contain the rays of as many as four overlapping spectra are next passed through a rock-salt or glass prism placed with its refracting edge parallel to the grating lines. This sorts out the different narrow spectral images, without danger of overlapping, and after their passage through the prism we find them again and fix their position by means of the bolometer, which for this purpose is attached to a special kind of spectrometer, where its platinum thread replaces the reticule of the ordinary telescope. This is very difficult work, especially in the lowermost spectrum, where I have spent over two weeks of consecutive labor in fixing a single wave-length.

The final result is I think worth the trouble however, for as you see here, we are now able to fix with approximate precision, and by direct experiment, the wave-length of every prismatic spectral ray. The terminal ray of the solar spectrum, whose presence has been certainly felt by the bolometer, has a wave-length of about 28,000 (or is nearly two octaves below the "great A" of Frauenhofer).

So far it appears only that we have been measuring *heat*, but I have called the curve that of solar "energy," because by a series of independent investigations, not here given, the selective absorption of the silver, the speculum-metal, the glass and the lamp-black (the latter used on the bolometer-strip), forming the agents of investigation, has been separately allowed for. My study of lamp-black absorption, I should add in qualification, is not quite complete, I have found it quite transparent to certain infra-red rays, and it is very possible that there may be some faint radiations yet to be discovered even below those here indicated.

In view of the increased attention that is doubtless soon to be given to this most interesting but strangely neglected region, and which, by photography and other methods, is certain to be fully mapped hereafter, I can but consider this present work less as a survey than as a sketch of this great new field, and it is as such only that I here present it.

All that has preceded is subordinate to the main research, on which I have occupied the past two years at Allegheny, in comparing the spectra of the sun at high and low altitudes, but which I must here touch upon briefly. By the generosity of a friend of the Allegheny Observatory, and by the aid of General Hazen, Chief Signal Officer of the U. S. army, I was enabled last year to organize an expedition to Mount Whitney in Southern California, where the most important of these latter observations were repeated at an altitude of 13,000 feet. Upon my return I made a special investigation upon the selective absorption of the sun's atmosphere, with results which I can now only allude to.

By such observations, but by methods too elaborate for present description, we can pass from the curve of energy actually observed, to that which would be seen, if the observer were stationed wholly above the earth's atmosphere, and freed from the effect of its absorption.

The salient and remarkable result is the growth of the blue end of the spectrum, and I would remark that while it has been long known from the researches of Lockyer, Crova and others, that certain rays of short wave-length were more absorbed than those of long, that these charts show *how much* separate each ray of the spectrum has grown, and bring, what seems to me, conclusive evidence of the shifting of the point of maximum energy without the atmosphere toward the blue. Contrary to the accepted belief, it appears here also that the absorption on the whole grows less and less, to the extreme infra-red extremity: and on the other hand, that the energy before absorption was so enormously greater in the blue and violet, that the sun must have a decidedly bluish tint to the naked eye, if we could rise above the earth's atmosphere to view it.

But even were we placed outside the earth's atmosphere, that surrounding the sun itself would still remain and exert absorption. By special methods, not here detailed, we have at Allegheny compared the absorption, at various depths, of the sun's own atmosphere for each spectral ray, and are hence enabled to show with approximate truth, I think for the first time, the original distribution of energy throughout the visible and invisible spectrum, at the fount of that energy, in the sun itself. There is a surprising similarity you will notice, in the character of the solar and telluric absorptions, and one which we could hardly have anticipated *à priori*.

Here too, violet has been absorbed enormously more than the green, and the green than the red, and so on, the difference being so great, that if we were to calculate the thickness of the solar atmosphere on the hypothesis of a uniform transmission, we should obtain a very thick atmosphere, from the rate of absorption in the infra-red alone, and a very thin one from that in the violet alone.

But the main result, seems to be still this, that as we have seen in the earth's atmosphere, so we see in the sun's, an enormous and progressive increase of the energy toward the shorter wave-lengths. This conclusion, which, I may be permitted to remark, I anticipated in a communication published in the *Comptes Rendus* of the Institute of France as long since as 1875, is now fully confirmed, and I may mention that it is so also by direct photometric methods, not here given.

If then we ask how the solar photosphere would appear to the eye, could we see it without absorption, these figures appear to show conclusively that it would be *blue*. Not to rely on any assumption, however, we have by various methods at Allegheny, reproduced this color.

Thus (to indicate roughly the principles used), taking three Maxwell's discs, a red, green and blue, so as to reproduce white, we note the three corresponding ordinates at the earth's surface spectrum, and comparing these with the same ordinates in the curve giving the energy at the solar surface; we re-arrange the discs, so as to give the proportion of red, green and blue which would be seen *there*, and obtain by their revolution a tint which must approximately represent that at the photosphere, and which is most similar to that of a blue near Frauenhofer's "F."

The conclusion then is that while all radiations emanate from the solar surface, including red and infra-red, in greater degree than we receive them, that the blue end is so enormously greater in proportion, that the proper color of the sun, as seen at the photosphere, is blue—not only "blueish," but positively and distinctly blue; a statement which I have not ventured to make from any conjecture, or on any less cause than on the sole ground of long continued experiments, which, commenced some seven years since, have within the past two years irresistibly tended to the present conclusion.

The mass of observations on which it rests must be reserved for more detailed publication elsewhere; at present I can only thank the Association for the courtesy which has given me the much prized opportunity of laying before them this indication of methods and results.

II. Geology and Natural History.

1. *Contributions to Mineralogy;* by F. A. Genth. — Dr. Genth has recently published some new observations bearing upon the subject of the alteration of corundum, so ably investigated by him in 1873 (see this Journal, vi, 461). The cases noted by him are as follows: (1) *Corundum altered into spinel.* At the Carter mine, Madison County, N. C., corundum is found in white and pink crystals, and in irregular grayish white or white cleavage masses enveloping a variety of a delicate pink color. This corundum is often more or less completely changed to a massive greenish black spinel of a fine granular structure, but rarely showing octahedral crystals in the compact mass. The spinel occasionally shows scales of prochlorite into which it finally passes; an analysis showed it to have essentially the composition $(Mg, Fe)Al_2O_4$. The corundum from Shimersville, Penn. (see p. 156), is also in part altered to spinel; the crystals contain numerous brilliant crystals of menaccanite. (2) *Corundum altered into zoisite.* A new locality has been found in Towns County, Ga. (3) *Altered to feldspar and mica* (damourite). Cases of the probable alteration of corundum into feldspar have been observed at Unionville, and at the Black Horse Farm near Media, Penn. At the Presley Mine, Haywood County, N. C., feldspar and mica have been observed together as alteration products; the large crystals of corundum of a grayish-blue color contain patches of

white, cleavable feldspar often surrounded by mica, in other cases a small nucleus of the original mineral is surrounded by an aureole of delicate sub-fibrous mica; one crystal of muscovite contained in the center remnants of a smooth bluish-gray cleavable corundum; another mass resembled a coarse granite consisting of albite, muscovite and scattered remnants of grayish-blue corundum; large (one foot in diameter) crystals of corundum occur at Belts' Bridge, Iredell County, N. C., which are more or less completely altered to mica, though they also contain radiating crystalline masses of black tourmaline; from the mica schists near Bradford, Coosa County, Alabama, fine hexagonal crystals have been obtained, consisting of a central part of corundum of a brown and bronze color, inclosing grains of menaccanite, and surrounding this is a perfect ring of sub-fibrous greenish-white mica; other crystals are almost entirely altered, and, often being flattened out, they form irregular nodules in the mica schist, the mica is sometimes scaly, sometimes very fine-grained and compact. Flattened nodules of mica, enclosing a nucleus of corundum also occur at the Haskell mine, Macon County, N. C. (4) *Corundum altered to margarite:* various new localities are mentioned by Dr. Genth. (5) *Altered into fibrolite:* crystals from Shoup's Ford, Burke County, N. C., consist of brown corundum with a thin shell (5mm.) of fine fibrous radiating white fibrolite. (6) *Altered into cyanite:* a specimen from Statesville, Iredell County, N. C., consisted of a nucleus of pink corundum with pale blue cyanite crystallized about it and presumably having resulted from its alteration; in another specimen from Wilkes County, N. C., the cyanite was still further altered to mica.

Dr. Genth also mentions cases of the alteration of orthoclase into albite from Upper Avondale, Delaware County; of talc into anthophyllite from Castle Rock, Delaware County, Penn.; of talc pseudomorph after magnetite from Dublin, Harford County, Md.; of altered gahnite from North Carolina and Cotopaxi. Numerous analyses are given of the various products of alteration mentioned above, and also of the following minerals: sphalerite and prehnite from Cornwall, Pa.; pyrophyllite from the Cross Creek colliery, Drifton, Luzerne County, Pa.; of beryl and allanite from Alexander County, N. C.; of niccolite from Silver Cliff, Colorado.

2. *Anthracite in Sonora, Mexico.*—Professor E. T. Cox, in an account of his observations in the Western States, presented to the American Association at Montreal, stated that near the Zaqui River, 120 miles east of Guaymus, anthracite of excellent quality constitutes two beds, 15 feet apart, in a formation that is probably of true Carboniferous age. The upper bed is 6 to 7 feet thick, the lower 12; and the associated rocks are siliceous shales and coarse breccia conglomerates dipping 35° to the eastward. A few fragments of fossil plants were obtained which Professor Cox has placed in the hands of Dr. Dawson for examination and report. Close to the anthracite are beds of lava and also quartz lodes, some of them rich in silver ores.

3. *Manual of Blowpipe Analysis, Qualitative and Quantitative, with a complete System of Determinative Mineralogy;* by H. B. CORNWALL. 308 pp. 8vo. New York, 1882. (D. Van Nostrand).—This volume includes the general range of topics ordinarily discussed under the head of Blowpipe Analysis. It is characterized by the excellent fullness and clearness with which the directions for manipulation and the statement of the various reactions are given, and will consequently be found easy of use by the beginner.

4. *A new family of Rugose Corals*, and description of the Genera Cyclophyllum, Aulophyllum and Clisiophyllum, by JAMES THOMSON, F.G.S. Proc. Phil. Soc. of Glasgow.—A valuable paper reviewing the history and characters of the genera mentioned, and instituting the family Diplocyathophyllidæ, based partly on the double cup, presented in a longitudinal section at the superior extremity of the corallum.

5. *Trees and Tree-culture.*—Two pamphlets before us are specially to be commended, viz:

The Culture and Management of our Native Forests for development as Timber or Ornamental Wood. By H. W. S. CLEVELAND. Published by the author, at Chicago (97 Washington st.). 16 pages, 8vo.—It is "an Essay, read by invitation to a committee of the Massachusetts Legislature, and to the National Forestry Congress at Cincinnati." Of this essay an "eminent botanist and tree-culturist in Illinois" writes: "I do not know when I have read anything on the subject so sensible, well put, and so clearly the outgrowth of practical observation and experience. It is refreshing to read anything which so readily commends itself to sound judgment and plain common sense." We think so too.

Notes on the Native Trees of the Lower Wabash and White River Valleys in Illinois and Indiana. By ROBERT RIDGWAY. —A pamphlet of 50 papes, extract from the Proceedings of the U. S. National Museum; very interesting statistics relative to trees of a district peculiarly rich and luxuriant in its native forest growth.

And now, at this moment, we receive the first number of

The American Journal of Forestry, edited by FRANKLIN B. HOUGH, Ph.D., Chief of the Forestry Division, U. S. Department of Agriculture (Cincinnati: Clark & Co. $3 per annum), commenced with much spirit by a gentleman who has devoted a great part of his life to this subject, and is the most prolific writer upon it. To this opening number he contributes an article on "The Forestry of the Future." Professor Spalding of Ann Arbor writes on "Forestry in Michigan." Dr. Wander on Larch-wood, and Mr. H. C. Putnam on "Forest Fires," which, we are glad to see, are preventable by proper regulations. A. G.

6. *Familien Podostemaceæ. Studier af* Dr. EUG. WARMING. VI Afhandling.—Warming has now brought out the second part of his studies of *Podostemaceæ*, the first part having been devoted mainly to our *Podostemon ceratophyllum*. The present part, just

issued, treats of the organs of vegetation of *Castelnavia princeps* from Brazil, and two species of *Dicræa* from Ceylon; also of the fructification of *Podostemon*, *Mniopsis*, *Dicræa* and *Castelnavia*, with 9 plates. The letter-press is in Swedish; but an abstract and the detailed explanation of the plates are added in French. Dr. Warming has removed to Stockholm, where he is now professor of botany in the High-school. A. G.

7. Professor G. L. GOODALE, of Harvard University, has returned from his year's absence in Europe, mainly devoted to a study of Botanical Laboratories and Gardens, and has resumed his work at Cambridge.

8. *Bulletin of the U. S. Geological and Geographical Survey of the Territories*, F. V. HAYDEN, Geologist-in-charge. Vol. vi, No. 3. 598 pp. 8vo. Washington, 1882.—This Bulletin, the last of the series,—a very valuable series to science—contains the following papers: Preliminary lists of the works and papers relating to the orders of Cete and Sirenia, by JOEL A. ALLEN, pp. 397–563; New Moths with partial catalogue of Noctuæ, by A. R. GROTE; New Moths, principally collected in Maine, with notes on noxious species and remarks on classification, by A. R. GROTE.

9. *On the Young Stages of Osseous Fishes*, by ALEXANDER AGASSIZ. Part iii, with 20 plates. July, 1882. From the Proceedings of the American Academy of Arts and Sciences, vol. xvii.

III. ASTRONOMY.

1. *A Method for Observing Artificial Transits;* by J. M. SCHAEBERLE. (Communicated by the author.)—As many astronomers who intend to observe the coming transit of Venus have neither the time nor means for making the necessary arrangements to practice on artificial transits, the simple method here proposed may be advantageously employed. Instead of observing an artificial sun and planet placed at a distance of several thousand feet from the observer, I would suggest that the real sun be observed, and the planet Venus to be represented by a circular disk, held, in the common focus of the objective and eye-piece, by means of a narrow metallic arm fastened to the eye-piece.

The relative motion of the sun and Venus can then be produced by so adjusting the rate of the driving clock that the angular motion of the telescope on the hour axis shall exceed the diurnal motion of the sun by seventeen seconds of time per hour. In this way, as the atmospheric disturbances of the sun's limb are real, a near approach to the phenomena observed during an actual transit will result. If a light shade-glass is employed, the opaque disk will be seen before it comes into apparent contact with the sun. The observer can, however, by an exercise of the will, confine his whole attention to the sun's limb.

By using a heavier shade-glass the disk will not be seen until it

is projected against the image of the sun. The angular diameter of Venus at the time of transit being about 65″, the diameter of the opaque disk should be $65 \cdot t \sin 1'' = 0{\cdot}00031 \cdot l$, l being the focal length of the telescope used. The position angle of the point of contact can be changed at will by simply moving the telescope in declination.

Ann Arbor, Mich., Oct. 9, 1882.

2. *Annals of the Astronomical Observatory of Harvard College.* Vol. xiii, Part I. *Micrometric Measurements*, made with the Equatorial Telescope of fifteen inches aperture during the years 1866–1881, under the direction of JOSEPH WINLOCK and EDWARD C. PICKERING, successive Directors of the Observatory. 204 pp. 4to. Cambridge, 1882.—The micrometric measurements here published include all the miscellaneous micrometric work made in the Harvard Observatory during the years mentioned up to the beginning of 1882. They are but a small part of the work of the Observatory, and since 1879 this has been mainly photometric. The results are given under the heads: Double Stars; Nebulæ; Satellites of Saturn, Uranus and Neptune; Satellites of Mars, 1877 and 1879; Asteroids; Comets; Occultations. The observations on Double Stars were mostly made under the direction of Professor Winlock, but to these are added a few others made by Professors W. C. and G. P. Bond, published by the American Academy of Arts and Sciences and the Astronomische Nachrichten, and also of Mr. L. Waldo published in the latter journal. Along with the results of micrometric measurements of Nebulæ are also given the results of spectroscopic observations and descriptive notes. The dates of a few unreduced observations are also given.

3. *On the Photographic Spectrum of Comet (Wells) I*, 1882; by WILLIAM HUGGINS. (From the Proceedings of the Royal Society.)—On the evening of Wednesday, May 31, I obtained a photograph of the spectrum of this comet, with an exposure of one hour and a quarter. A spectrum of α Ursæ Majoris was taken through the other half of the slit, for comparison.

The photograph shows a strong continuous spectrum extending from about F to a little beyond H. In this continuous spectrum I am not able to distinguish the Fraunhofer lines. In this comet, therefore, at this time, the original light, giving a continuous spectrum, must have been much stronger relatively to the sunlight reflected than was the case in the comet of last year. It should be stated that the greater faintness of the present comet made it necessary to use a more open slit, which would cause the Fraunhofer lines to be less distinct; but the lines G, H and K are to be clearly seen in the star's spectrum taken under the same conditions.

Eye observations by several observers on the visible spectrum of the comet had already shown that this comet, for the first time since spectrum analysis was applied to the light of these bodies in 1864, gives a spectrum which differs essentially from the hydrocarbon type to which all the comets previously examined spectroscopically (about twenty) belong.

In the visible spectrum bright lines, presumably of the vapor of sodium, and some other bright lines and bright groups of lines, have been seen. The hydrocarbon bands in this part of the spectrum have been suspected to be present by some observers.

The photographic spectrum differs greatly from that of the comet of last year.* I am not able to see the cyanogen group in the ultra-violet beginning at wave-length 3883, nor are the other two groups between G and *h* and between *h* and H to be detected.

The continuous spectrum which extends from below F to a litte distance beyond H contains at least five brighter spaces, which are doubtless groups of bright lines, though it is not possible in the photograph to resolve them into lines. These places of greater brightness can be traced beyond the border of the continuous spectrum on the side which corresponds to the coma of the comet on the side next the sun. The light from this part of the comet gave a very much fainter continuous spectrum, for on the photographic plate it appears to be almost wholly resolved by the prism into these bright groups. One or two fainter groups are suspected to be present, but they are too indistinct to admit of measurement.

The five stronger bright groups are too faint at the commencement and ending of each group to permit of more than a measurement of the estimated brightest part of each bright space.

The positions of these brightest parts are:

$$\lambda\ 4769,\ \lambda\ 4634,\ \lambda\ 4507,\ \lambda\ 4412,\ \lambda\ 4253.$$

Professor A. Herschel and Dr. von Konkoly pointed out long ago that the spectra of periodic meteors belonging to different swarms of meteors differ from each other, and the meteorites which come down to us differ greatly in their chemical constitution. It is not surprising to find the matter of the nucleus of this comet to exhibit a chemical difference from that of other comets.

4. *Publications of the Washburn Observatory of the University of Wisconsin.* 8vo. Vol. i. Madison, 1882. Edward S. Holden, Director.—This volume contains the description of the Observatory buildings and instruments; a catalogne of 195 stars observed at Detroit by Mr. Schæberle, and reduced at the Washburn Observatory; a list of 27 new nebulæ; a list of 60 new double stars discovered by Mr. Holden; a list of 88 new double stars discovered by Mr. Burnham at the Observatory; measures by Mr. Burnham of 152 selected double stars; observations of 84 red stars and a list of 27 new red stars; observations of the great comet of 1881. The assumed position of the meridian circle of the Observatory is:

North latitude, 43° 4′ 36″·64. Longitude, 89° 24′ 28″·31.

5. *Washington Observations for* 1878. Appendix II.—The longitude of the meridian circle of the John C. Green School of Science, at Princeton, N. J., was determined by H. M. Paul of the U. S. N. Observatory, and Professor Young; the result being that it is $0^h\ 9^m\ 34^s{\cdot}538$ east of the central dome of the U. S. N. Observatory at Washington, D. C.

* Proc. Roy. Soc., vol. xxxiii, p. 1.

IV. Miscellaneous Scientific Intelligence.

1. *A new method of measuring Heights by means of the Barometer;* by G. K. Gilbert. (U. S. Geological Survey, J. W. Powell, Director. Extract from the Annual Report for 1880–81).—Mr. Gilbert has made a very important contribution to the subject of practical hypsometry, having developed a new method of measuring differences of altitude by the barometer, which though somewhat limited in its application, gives under favorable conditions results which are decidedly more accurate than those obtained by the methods now in use. The following notice will make clear the principles upon which the new method is based, while for the thorough discussion of the subject reference must be made to the original memoir which leaves little to be desired in this respect. Mr. Gilbert devotes the opening thirty pages of his memoir to a general discussion of the problem of determining differences of altitude by means of the barometer, describing the principal methods now employed, and the various disturbing conditions of temperature, humidity and so on, with the devices for the elimination of errors due to them. This discussion brings out very fully and clearly the unavoidable difficulties with which ordinary hypsometric methods are beset, and prepares the way for the presentation of the new method proposed.

This method is briefly, as follows. Two *base stations* are chosen, whose known difference in vertical height ("*vertical base line*," determined by the spirit-level) is as great, and whose horizontal distance is as small, as practicable; and at these, frequent observations of the barometer are made during the day. Also similar observations are taken at the third station whose altitude is to be determined. No observations to determine the temperature or humidity are required. The readings, corrected for index error and temperature of the mercury, are collected in groups of three, coincident for the two base stations and the new station. From these the approximate height (A') of the new station, and that of the base line (B') are calculated as usual, but without the ordinary corrections, that is, assuming that the air is dry and at a uniform temperature of 32° F. Then if the known true height of the base line is B, the true height (A) of the new station is given by

$$\frac{B'}{B}=\frac{A'}{A} \qquad (1)$$

For, the weight (W) of the air column between the two base stations, determined by the barometer, is equal to the product of the mean density (d) of the column, multiplied by the height (B) and by a constant factor (E)

$$W = d\,B\,E \qquad (2)$$

Also, as B' is the approximate height of the same column, on the assumption that its mean density (d') is that which would exist if the air were dry and at 32° F.

$$W = d' B' E \qquad (3)$$

And from (2) and (3) $$\frac{B'}{B} = \frac{d}{d'}.$$

The ratio of the approximate height (B') to the true height (B) of the base line is therefore a measure of the temporary condition of the column of the base line with respect to density. Similarly the corresponding ratio of the approximate height (A') to the true height (A) of the new station measures the same condition as regards density, for the column between the new station and the lower base station, and hence follows equation (1).

In equation (1) it is assumed that the temporary condition of the two air columns named is identieal, or in other words that the temporary accidents of temperature and moisture affect both columns alike. Practically the comparison of the computed and true heights of the base line gives a coefficient expressive of the temporary local variation of density, and this is applied in the simultaneous determination of the height of the other partially coincident air column.

Equation (1) above is readily transformed so as to be useful in practice. If L, U, N, represent the altitudes of the lower and upper base stations and the new station respectively (where it is assumed that $L < N < U$) and if l, u, n represent respectively the synchronous readings of the barometer at the corresponding stations, then the approximate heights of the base line, and of the new station above the lower base station respectively will be expressed, in accordance with the familiar logarithmic law, by

$$C(\log l - \log u) \text{ and } C(\log l - \log n)$$

where C is a constant. Substituting these values in equation (1) we obtain

$$a = B\frac{\log l - \log n}{\log l - \log u}.$$

This expression would give the required height, if the distribution of aqueous vapor were uniform and the air column were uniform in temperature. As this is not true, however, a thermic correction must be introduced allowing for the effect of temperature and aqueous vapor, and this is obtained as follows: The mean thermic density of the air column, between the new station and lower base station, is assumed to be equal to that of the stratum midway between the two, the altitude of which is $\frac{N+L}{2}$. Similarly the mean thermic density of the column between the two base stations is assumed equal to that of a stratum whose height is $\frac{U+L}{2}$. The vertical space between these two midway strata is

$$\frac{\mathrm{U+L}}{2} - \frac{\mathrm{N+L}}{2} = \frac{\mathrm{U-N}}{2} = \frac{\mathrm{B-A}}{2}.$$

The difference between the two mean densities will be found by multiplying the number of units in this vertical space by the thermic density for each unit of vertical space. The rate of thermic increase being assumed to be uniform from the ground upward, it may be supposed that at some height (call it $\frac{D}{2}$) its total amount becomes equal to the density at the ground, and becomes unity when expressed in terms of the initial density. The thermic increase of density for each unit of vertical space is then expressed by $1 \div \frac{D}{2}$ or $\frac{2}{D}$, and the expression for the difference between the mean thermic densities becomes

$$\frac{B-A}{2} \times \frac{2}{D} = \frac{B-A}{D}.$$

This denotes the fraction by which the thermic increase of density affects the relative densities of B and A; it also expresses the fraction by which the deduced altitude A is affected by the thermic variation of density. The correction is therefore

$$\frac{A\,(B-A)}{D}.$$

The original assumption of uniformity of temperature and humidity made the density too great, and consequently the height too small. Hence the full formula should read

$$A = B\frac{\log l - \log n}{\log l - \log u} + \frac{A(B-A)}{D}.$$

This formula may be readily modified to correspond to the case where the relative heights of the three stations ($L < N < U$) is not that assumed above.

The constant D in the above equation must be determined experimentally. As stated, $\frac{2}{D}$ is the increment of thermic density for an ascent of a unit of space, and $\frac{D}{2}$ is the vertical distance at which the total increment is unity. D is therefore to be expressed in the same linear units as A and B and is a function of the vertical distribution of heat and moisture in the atmosphere. It represents consequently a perpetually fluctuating quantity for which only the average value can be obtained. The author proposes to ascertain its value by applying the formula to the computation of altitudes already known, and then deducing the value of D which will give the best average result. This method was applied to the case of observations taken by the California Geological Survey at Sacramento, Colfax and Summit, extending over a series of nearly three years; also to observations given by Rühlmann for three stations on the Miesing taken during a week in August, 1857. It was found that a wide variation in the

magnitude of the increment existed, both for different hours of the day and for different seasons of the year. The average value accepted is 490,000 feet (or 149,349 meters), so that the formula reads

$$A \text{ (in feet)} = B\frac{\log l - \log n}{\log l - \log u} + \frac{A(B-A)}{490{,}000}.$$

The variation in the force of gravity is neglected on the ground that its variation affects the air column to be measured and the standard column (base line) in nearly equal degrees, so that its influence is approximately eliminated.

Mr. Gilbert has made an extended series of comparative tests between the new method and those now in general use, for the discussion of which reference must be made to the original memoir. In general, they show that the new method gives results of decidedly more accuracy than the others, sufficient to justify its substitution for them in cases where the conditions required (of two base stations properly situated) can be realized, and where the extra expense of a second station is not too serious an element.

The author, having established the value of the method proposed, goes on to consider possible improvements in the formula, involving a more accurate determination of the constant D, a provision for diurnal and annual periodicity and various other related points. He also discusses the limitations to the application of the new method; these are obviously considerable, but it is believed that it will probably prove applicable to the greater part of the work done in the country during the years immediately to come, in cases where the more accurate method by the use of the theodolite and allied instruments is out of the question. For the practical application of the formula a table is given, from which the value of the thermic term $\frac{A(B-A)}{490{,}000}$, can be immediately obtained. An ingenious graphic table is also added to take the place of the other, which allows the determination of the same value without the labor of a double interpolation, otherwise often necessary.

2. *Professional Papers of the Signal Service.* No. 4. Report of the Tornadoes of May 29 and 30, 1879, in Kansas, Nebraska, Missouri and Iowa; by J. P. Finlay. No. 7. On the Character of Six Hundred Tornadoes; by J. P. Finlay.

The first of these papers is a monograph of 116 pages, and contains 29 maps and numerous other illustrations of thirteen tornadoes that occurred on the days and in the States named. The second is a catalogue of six hundred tornadoes that have occurred in the United States since 1794. By far the larger portion are, however, comprised in the last decade. Classified by months, these tornadoes occurred as follows:

January, 7.	April, 97.	July, 90.	October, 15.
February, 21.	May, 81.	August, 47.	November, 22.
March, 37.	June, 112.	September, 50.	December, 9.

The paper is accompanied by suggestions of methods of investigation and a statement of peculiarities of tornado clouds and suggestions for avoiding their violence. The numbers occurring in different States are tabulated, and a chart illustrating the frequency of tornadoes is constructed therefrom.

These papers will probably be more useful for the collections of facts contained in them than for the conclusions which the collector has himself deduced. Thus, in constructing the chart of frequency in different localities, the numbers for different States and Territories seem to be used without any correction for the size of the States, the period during which the observations can be presumed to have been made, or the facilities for securing reports of tornadoes that have occurred. The map is specially shaded to represent the two tornadoes of Vermont and the one of Rhode Island against the thirty-five of New York State, and the one tornado of the Indian Territory and one of Arizona against the sixty-two of Kansas.

3. *The Elements of Forestry*, designed to afford information concerning the planting and care of Forest Trees for ornament or profit, and giving suggestions upon the creation and care of woodlands, with the view of securing the greatest benefit for the longest time, particularly adapted to the wants and conditions of the United States, by FRANKLIN B. HOUGH, Ph.D., Chief of Forestry Division, U. S. Dept. of Agriculture, Member of the American Philosophical Society, etc. 382 pp. 8vo. Cincinnati, 1882. (Robert Clarke & Co.)

The Geological Record for 1878, edited by Wm. Whitaker and W. H. Dalton. 496 pp. 8vo. London. 1882. (Taylor & Francis.)

The Scientific evidences of Organic Evolution, by G. J. Romanes, F.R.S. Nature Series. 88 pp. 12mo. London. 1882. (Macmillan & Co.)

Synopsis of the Classification of the Animal Kingdom, by H. Alleyne Nicholson, Prof. Nat. Hist. Aberdeen. 130 pp. 8vo, with many illustrations. Edinburgh and London. 1882. (Wm. Blackwood & Sons.) A very convenient synopsis for the student, well illustrated.

Report of an examination of the Upper Columbia River and the Territory in its vicinity in September and October, 1881, to determine its navigability and adaptability to steamboat transportation. Made by direction of the Commanding General of the Dept. of the Columbia, by Lieut. T. W. Symons, Corps of Engineers U. S. A., Chief Engineer of the Dept. of the Columbia. 134 pp. large 8vo. with 26 maps. Washington. 1882. Senate document No. 186.

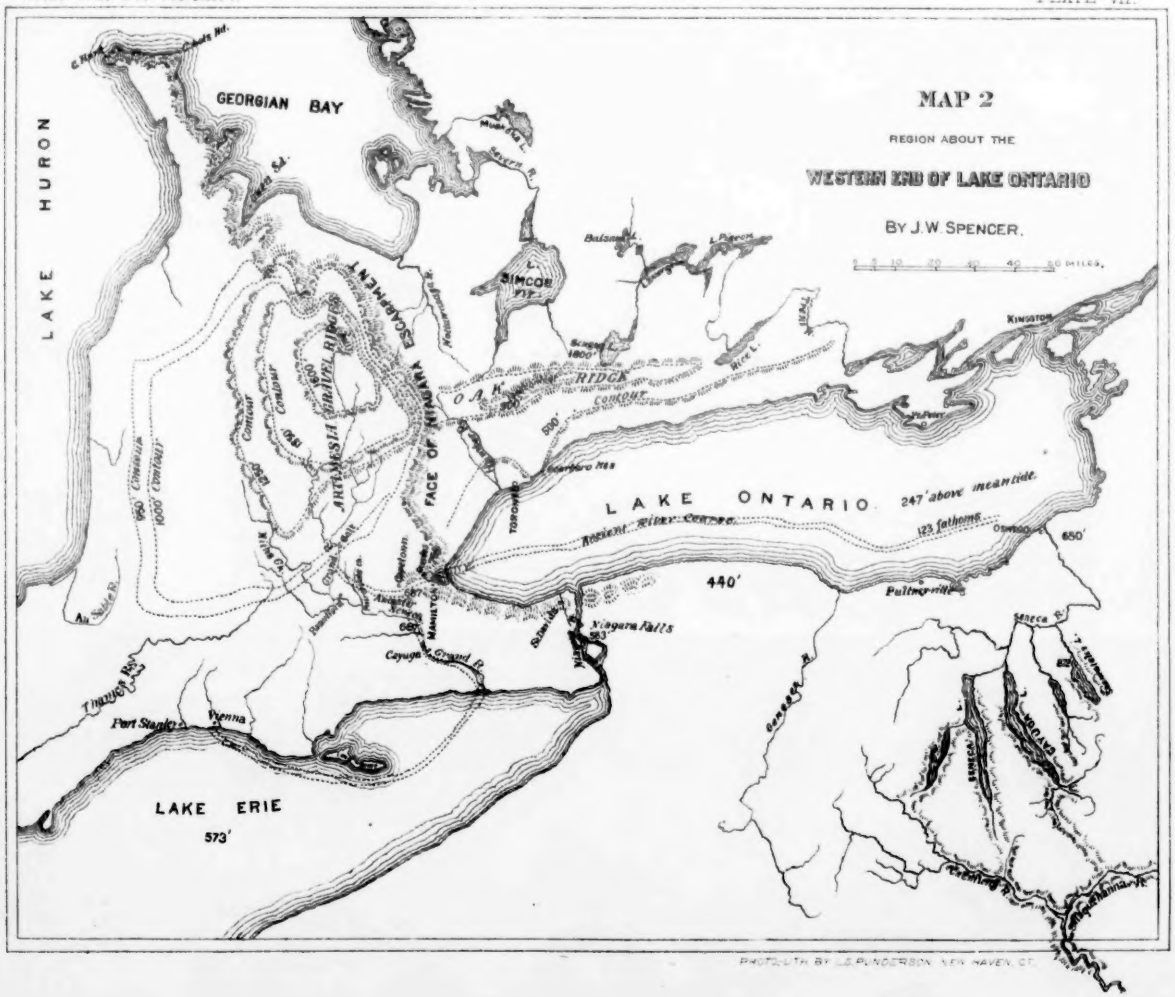
Annual Report upon the Surveys of the Northern and Northwestern Lakes, in charge of C. B. Comstock, Major of Engineers, Brevet Brigadier-General U. S. A. Appendix TT of the Annual Report of the Chief of Engineers for 1881. Washington.

Practical Microscopy, by George E. Davis. 335 pp. 8vo, with a colored plate. London, 1882 (David Bogue).

Lehrbuch der Vergleichenden Anatomie der Wirbelthiere auf Grundlage der Entwicklungsgeschichte bearbeitet von Dr. Robert Wiedersheim, Professor in Friburg, I. B. Erster Theil. 476 pp. 8vo. Jena. 1882. (Gustav Fischer.)

Acephalés: Etudes locales et comparatives. Extrait du Systême Silurien du Centre de la Bohême. vol. vi. By Joachim Barrande. 536 pp. 8vo. with 10 plates. 1881. Paris, Rue de l'Odéon. No. 22.

Mémoires sur les Terrains Crétacé et Tertiaires, préparés par feu André Dumont, pour servir à la description de la Carte Géologique de la Belgique, édités par M. Mourlon. Tome iv. Terrains Tertiaires, 3me. Partie. Bruxelles. 1882.


MAP 2
REGION ABOUT THE
WESTERN END OF LAKE ONTARIO
BY J.W. SPENCER.
LAKE HURON
GEORGIAN BAY
LAKE ONTARIO
247' above mean tide.
LAKE ERIE
573'
440'
650'
Niagara Falls
Toronto
Kingston
Oswego
Pulteneyville
Port Stanley
Vienna
Cayuga
Seneca R.
ARTEMESIA GRAVEL RIDGES
ESCARPMENT
FACE OF NIAGARA
OAK RIDGE
123 fathoms
Ancient River Course
PHOTO-LITH BY J.E. PUNDERSON, NEW HAVEN, CT.